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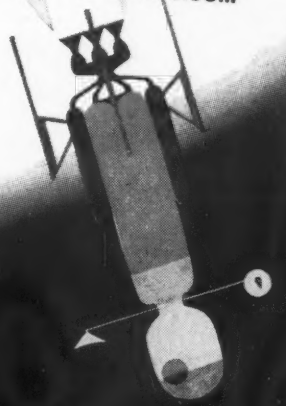
OCTOBER 1958



IN ARMY SPACE

THE OFFICIAL U. S. ARMY MAGAZINE

ARMY INFORMATION DIGEST

THE OFFICIAL MAGAZINE of the DEPARTMENT OF THE ARMY

The mission of ARMY INFORMATION DIGEST is to keep personnel of the Army aware of trends and developments of professional concern.

THE DIGEST is published under supervision of the Army Chief of Information to provide timely and authoritative information on policies, plans, operations, and technical developments of the Department of the Army to the Active Army, Army National Guard, and Army Reserve. It also serves as a vehicle for timely expression of the views of the Secretary of the Army and the Chief of Staff and assists in the achievement of information objectives of the Army.

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A SUBJECT as illimitable as the Universe calls for new departures, new concepts, new methods of visualizing a realm where old dimensions no longer apply. To illustrate this special issue of "The Army in the Space Age," Sp3 Wayne J. Stettler employs a conceptual approach which reflects, within the boundaries of two-dimensional paper and ink, the all-encompassing nature of the space realm, into which the Army is even now deploying in its pioneer quest for data of significance to the Nation's security and the progress of mankind.

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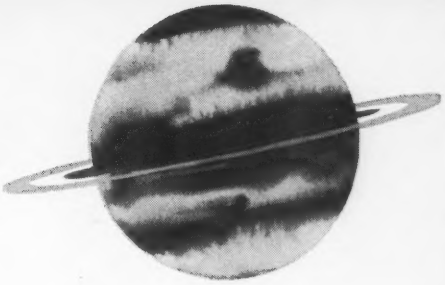

Our Defense Effort In Space

THE coordinated defense of our Nation and the maintenance of peace with honor make up the cornerstone upon which each program of the Department of Defense is built. Never before has this cornerstone shown greater strength. This is altogether fitting, for few military programs in history have been so significant or so complex as those which lead the assault upon the new frontier of outer space.

Working as a team, and utilizing the widespread talents that exist in all of our military departments, we are making great strides in ensuring the United States its proper place in this new environment. Both as these programs apply to the advancement of our knowledge and as they apply to the current and possible wartime uses of space for which the Department of Defense is responsible, each military department has made and will continue to make its vital contribution—in accordance with its capabilities for research in support of the total national effort.

IN THE several articles published in this special issue of ARMY INFORMATION DIGEST are reflected the dedication and interest which have been hallmarks of the Army's contributions to military space problems. As we continue to plan and program our proper research effort in space, these and later contributions, together with those of the Navy and Air Force, will add to that single effort which must be the accomplishment of the Department of Defense in fulfilling its military-scientific responsibilities to the American people.

Roy W. Johnson

ROY W. JOHNSON
Director
Advanced Research Projects Agency

Fact Is Pushing Fancy

FACT, at last, is overtaking fiction in space stories. Doubtless this is the necessary sequence, for it may be that man must first pioneer in his imagination before he undertakes an actual exploration.

Some seventeen hundred years ago a Greek satirist, Lucian, sent a fictional man to the moon by having him sail, foolhardily, beyond the Pillars of Hercules where a waterspout caught him up and squirted him the rest of the way. Centuries later one of the greatest of astronomers, Johannes Kepler, wrote of a man who got to the moon by supernatural means. Numerous imaginary trips to the moon were made within a short time after Galileo's discoveries with his telescope, and they have continued on down to the present, via Cyrano de Bergerac (first to use a fictional rocket to transport his man), Jules Verne, H. G. Wells and a long list of others, some using one dreamed-up method of travel, some another until well within this century the rocket, not needing air for its propulsive power, came to be recognized as the device for penetrating space.

Arthur C. Clarke, twice chairman of the British Interplanetary Society, a respected writer of fiction and fact about space, says ". . . It cannot be doubted that these countless stories—and not merely those few with a carefully scientific basis—have done a great deal to bring closer the achievements of which they told . . . The conquest of space must obviously have a fundamental appeal to human emotions for it to be so persistent a theme over such a span of time. It is a little strange, therefore, to think that in what might be called its classic form, the space-travel story soon will disappear, for history is overtaking imagination. When the first rocket lands on our satellite, the romantic writers will have lost the Moon; but it will be a small sacrifice, for the Universe will still remain as their playground."

ARMY INFORMATION DIGEST

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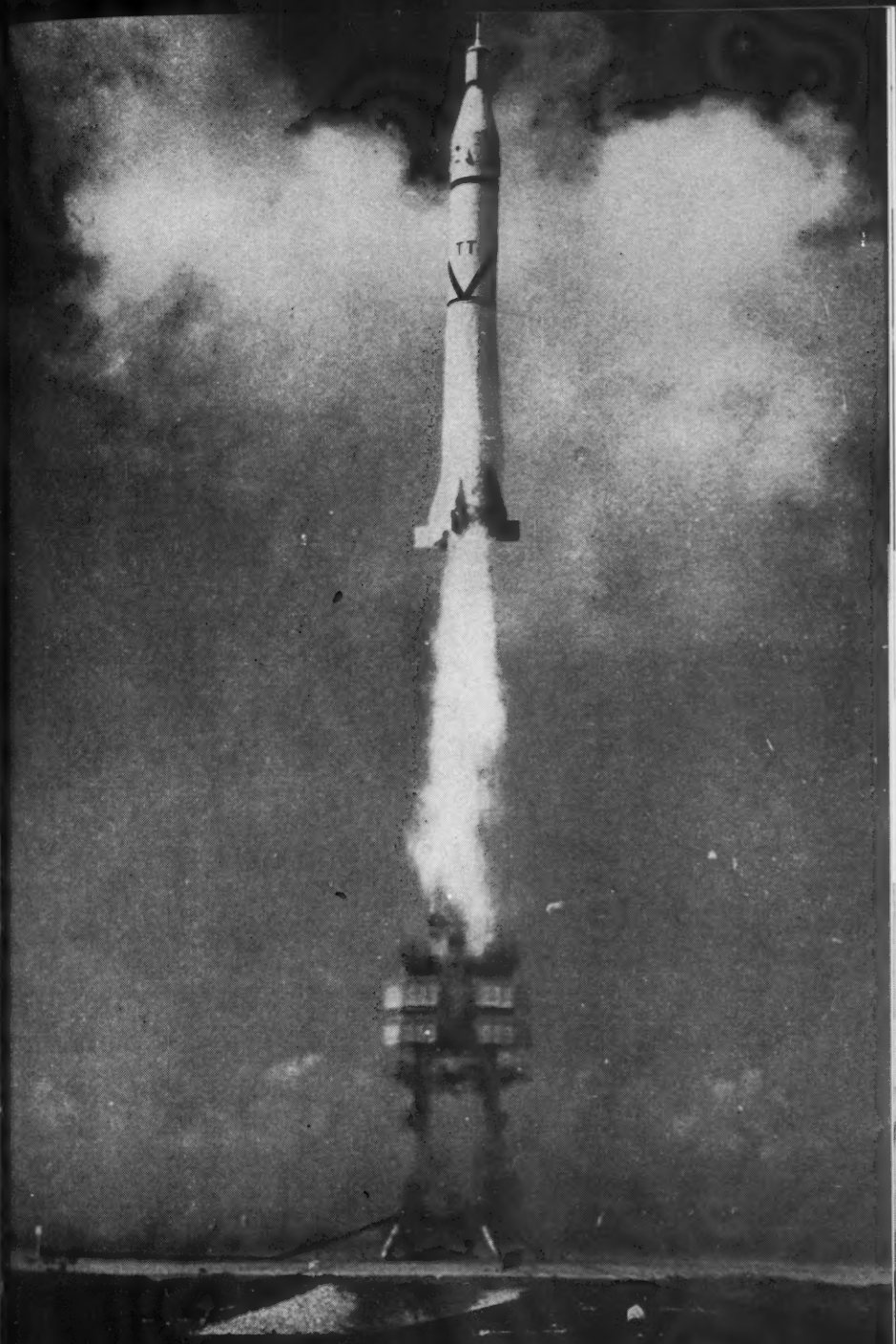
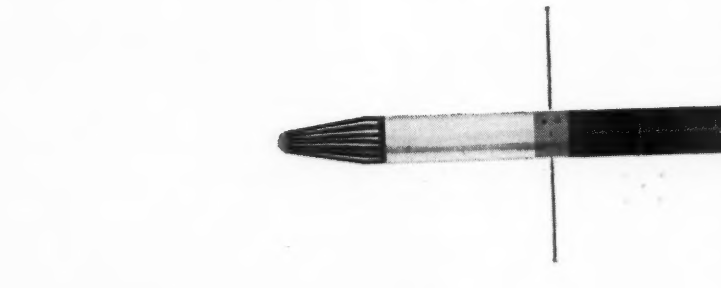
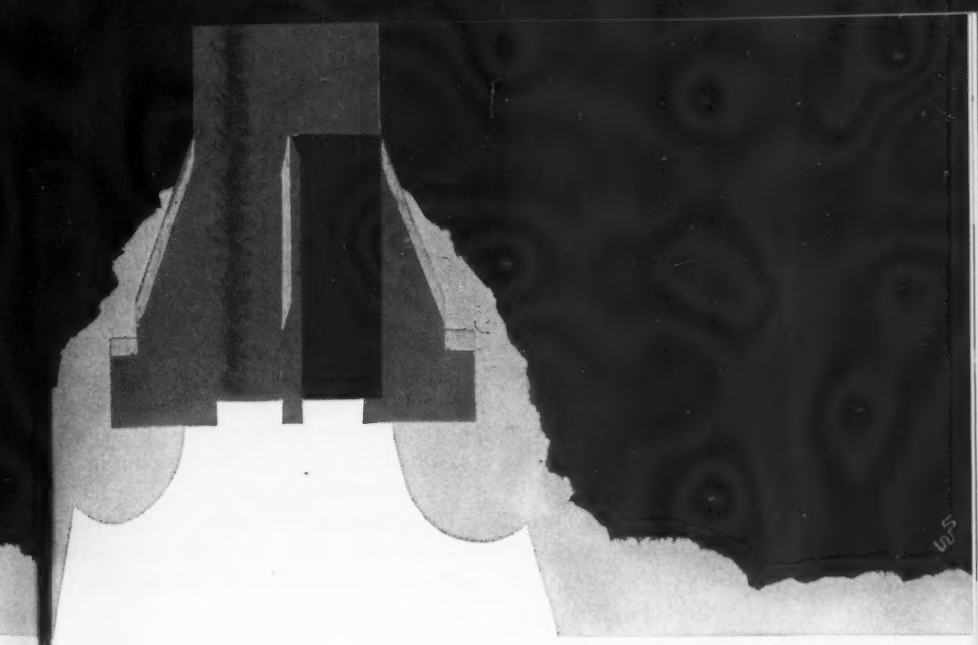


Explorer IV Heads for Outer Space

History written in the skies

THE EXPLORER





SATELLITES

and how we launched them

Major General J. B. Medaris

IN MORE than a million years of existence on earth, until the twentieth century, man was limited in his explorations to a thin terrestrial patina that supported his lateral wanderings.

By the middle of this century man had crawled to the peak of the highest mountain, probed the ocean's depths, and survived polar winters. His greatest travel triumphs came when he took to the air in flying machines, and within fifty years could circle half the globe non-stop, and climb nearly twenty miles above the clouds to survey a curving world below.

In this new-found quietness nearer the stars, man could not still an inward clamor to reach further toward infinity.

The first step upward was made by the Soviets, who gathered the fruits of a combined military-scientific research program to launch the earth's first satellite on 4 October 1957.

A startled Free World turned searching eyes from the circling Sputnik to preparations in the

MAJOR GENERAL J. B. MEDARIS is Commanding General, U. S. Army Ordnance Missile Command, Huntsville, Alabama.

United States for launching scientific satellites as America's contribution to the International Geophysical Year.

To implement this program, the U. S. Army, which had had pronounced success in long-range ballistic missile development, was given a new mission on 8 November 1957.

On that date the Department of Defense directed the Army Ballistic Missile Agency to prepare for an IGY satellite launching, using the Jupiter-C missile as the carrier.

ABMA was then less than two years old, having been activated 1 February 1956. But it was in an enviable position. Commanded at that time by the writer, with Dr. Wernher von Braun as Director of the Development Operations Division, its personnel comprised the Free World's most experienced missile team.

Its accomplishments were many. While under the leadership of Major General H. N. Toftoy at Redstone Arsenal, it had developed the 200-mile range Redstone.

After the formation of ABMA it had worked under crash procedures to refine the Redstone and place it in the hands of troops as soon as possible, and to develop the intermediate range Jupiter. The Jet Propulsion Laboratory, Pasadena, California, was the full working partner of ABMA in the satellite undertaking.

The team asked for only 90 days before launching.

On the 84th day following the order to prepare, Explorer I was launched from Cape Canaveral, Florida. It left the pad at 10:48

The Less You Know, The Easier It Looks

THE big headlines make it look easy when a man-made satellite goes into orbit, but for those who know the story behind the headlines, the putting up of a satellite is perhaps the most delicately complicated task man ever has set for himself. The scientific knowledge of thousands of men, the technical skills of other thousands are necessary to make just one successful shoot.

At the Army Ballistic Missile Agency, Huntsville, Alabama, 3,200 dedicated military and civilian scientists and technicians working as a single-minded team with the 2,000 equally competent and dedicated scientists and technicians at the Jet Propulsion Laboratory, Pasadena, California, were needed to put up the Explorers. If only one of these more than 5,000 men and women had made an undetected error, the end-results might have been an anti-climactic flop.

Complexity of the satellite itself, apart from the propulsion systems, is suggested by the fact that one of the simpler devices on Explorer III is a miniature tape recorder, developed by the State University of Iowa, that collected data on cosmic radiation encountered during the total orbit, played the information back on a signal from a ground station, after which the tape was automatically erased and reset, to be used again and again.

Other larger and more advanced satellites will follow the Explorers, each contributing something to the knowledge of space-searching man. There will be new concepts of peaceful as well as military uses, such as the all-seeing eye, the manned platform in space, world-wide communications relay stations, perfect weather forecasts, possibly weather control, and continuously unfolding knowledge of the universe. No man now can foresee more than a few of the wonders, the surprises to be encountered in investigation of space—the vastest of the frontiers that have challenged and lured man onward in progress.

p.m., Eastern Standard Time, 31 January 1958.

Seven minutes later, when it was placed in orbit, tense and jubilant workers relaxed for the first time in weeks. Other giant strides, some perhaps more spectacular in themselves, will be taken as man explores the universe. Few will equal Explorer I in public acclaim. It signaled the advent of the Space Age for the United States and friendly nations. The "Open House" observance of ABMA's second birthday at Huntsville the next day was transformed from a birthday party to a jubilant celebration by Huntsville citizens.

WITHIN five weeks after the successful orbiting of Explorer I, on 5 March 1958, the ABMA team was ready to try again. But this shoot was disappointing. After a highly successful launching of the first main stage, Explorer II was pushed rapidly on its course by the solid propellant second and third stages. But the fourth and final stage motor, which would have given the satellite orbital velocity, failed to ignite.

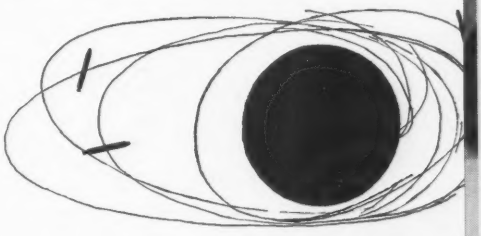
The next day another Jupiter-C missile from ABMA arrived at Cape Canaveral, and the elaborate and careful checkout procedure began. Carrying a satellite with instrumentation for experiments exactly like that in Explorer II, it was successfully launched on 26 March 1958, and Explorer III was placed in orbit.

In a repeat performance, on 26 July, still another Explorer was propelled into orbit by the mighty surge of a Jupiter C missile. Identical in external configuration to its predecessors, Explorer IV carried advanced instrumentation, including four separate radiation counters, which brought its weight to 38.43 pounds. Moving in a highly elliptical orbital band covering most of the earth's surface, Explorer IV was designed to investigate the phenomenon of high corpuscular radiation intensities detected by the earlier Explorers.

IT IS impossible for those not directly connected with the effort to appreciate the tremendous amount of dedicated labor, the variety of skills and ingenuity, painstaking care and high degree of teamwork necessary to erect these milestones. The story is that of a group of military and civilian specialists who had confidence, tenacity, experience and ability.

THE Explorers were placed in orbit by the Jupiter-C rocket, a four-stage vehicle which was originally conceived in 1955. During the Spring of that year, Army missile developers at Redstone Arsenal, under the technical leadership of Dr. Wernher von Braun, submitted a satellite proposal to the Department of Defense entitled Project Orbiter. This was prepared in cooperation with the Navy Bureau of Ordnance and the Jet Propulsion Laboratory.

The main stage for Project Orbiter was to be the Army's Redstone liquid-fuel ballistic missile,



developed at Redstone Arsenal under military direction by Dr. von Braun's group. The Redstone was to be capped by high-speed upper stages consisting of clusters of small solid propellant motors.

Later that year Project Orbiter was abandoned in favor of Project Vanguard, a more sophisticated design submitted by the Naval Research Laboratories.

Early in 1956, after the Army had been assigned the job of developing the Jupiter Intermediate Range Ballistic Missile, it was decided that the staging concept and the work already accomplished on Orbiter could make a great contribution to the Jupiter program.

RE-ENTRY SOLVED

THE aerodynamic heating problem associated with the re-entry of a ballistic missile had to be solved. This was one of the most challenging aspects of the IRBM program. The Army Ballistic Missile Agency, again joined by JPL, decided to use the Project Orbiter principle in this vital work.

The plan was to modify the proven Redstone workhorse missile for the main stage, and add solid propellant upper stages and a scaled-down Jupiter IRBM nose cone. Experiments on nose cone re-entry could then be made without the expense and added delay of waiting until the Jupiter itself was ready for test launchings.

The experimental missile was named the Jupiter-C because of its role in the Jupiter development. The C is an abbreviation of "Composite Re-entry Test Missile."

THE first launching of the Jupiter C, conducted in September 1956, was a complete success. The inert final stage traveled more than 3,000 miles southeast from Cape Canaveral, Florida, and reached an altitude of more than 680 miles. Other tests followed, and a significant step toward solving the re-entry problem for the Jupiter IRBM was achieved on 8 August 1957. President Eisenhower exhibited a Jupiter-C nose cone in November, announcing that the United States had found a workable solution to the aerodynamic heating problem. That cone was recovered by the Navy.

Attaining a promise of a satisfactory solution so early in the experiments was beyond the Army's fondest expectations. Several other Jupiter-C flights had been scheduled, but these were cancelled after the August success, and the hardware became available for other purposes.

PREPARING THE SATELLITE

WHEN the satellite launching order was received, much of what was required to do the job was already on hand, as a result of the re-entry experiments. Some preliminary work, dating back to Project Orbiter, had been performed on the satellite proper and orbit calculations. Certain modifications, however, were required on the launching vehicle. These were carried out by ABMA, which was responsible for the main stage, and JPL, which provided the high-speed upper assembly.

For its satellite carrier role, the Redstone was modified as follows:

1. Tanks were lengthened to hold more fuel and oxidizer.

2. A unique fuel mixture known as "hydyne" was employed in place

of the alcohol used in the tactical Redstone.

3. The forward section of the Redstone was modified to support the launcher of the high-speed stages, which consists of a spinning cylindrical "tub," supported on the axle and spun by electric motors in the Redstone nose section.

4. A special attitude control system was designed which positions the forward section of the Redstone booster to fire the high-speed stages in the correct direction at the apex of the booster trajectory.

The second stage of the missile consisted of a cylindrical ring of eleven solid motors, each six inches in diameter and approximately four feet long, each containing about fifty pounds of a solid propellant in a stainless steel case.

Fitting within the ring of eleven motors were three identical motors which compose the third stage. The final stage of one motor, with the satellite payload attached, was then added. The fourth stage motor was made of a slightly more energetic type fuel than that in the other stages.

LABORATORY CONTRIBUTIONS

THE 84 days prior to the first launching were filled with orderly, careful preparation at the Huntsville, Alabama, installation and the Pasadena Laboratory. Heading the work for the Army was Dr. von Braun, while Dr. J. E. Froehlich was in charge of the project at JPL.

Laboratories at the Missile Agency, staffed by some 3,200 military and civilian scientists, engineers and technicians, contributed specialized knowledge and skills to the Jupiter-C program. Only by examining their total contributions, and those of the 2,000 scientific and technical personnel at JPL,

Actual size model of satellite is examined by Maj. Gen. J. B. Medaris, Dr. Wernher Von Broun and Dr. Ernst Stuhlinger, at right, as other project officers look on.

Just before Explorer III launching, Maj. Gen. J. B. Medaris, Secretary of Army Wilber M. Brucker and Dr. Wernher von Braun confer near Jupiter C.

can one gain a perspective by which to appraise their achievements. *(See page 61.)*

Responsibility for the preliminary design, and the detailed structural, propulsion and mechanical design of the huge, 70-foot carrier vehicle, was assigned to the ABMA Structures and Mechanics Laboratory. This, in general, included increasing the size of the main thrust unit while reducing tank skin thickness to save weight; modifying the thrust unit to accommodate the special hydyne fuel; and developing a system to separate the thrust unit and instrument compartment.

The Laboratory also designed and developed the spin launchers for the JPL upper stages. Spinning the upper stages by means of electric motors provided stabilization similar to that of a rifle bullet.

In addition, the Structures and Mechanics Laboratory was the technical coordinator with JPL, and the project engineering unit within ABMA.

The Aeroballistics Laboratory had charge of the flight performance and aerodynamic problems, and in conjunction with JPL studied the feasibility of the project from the beginning. It planned the ascending trajectory and established the exact flight data for the firing, including the possible pattern of expected largest deviation. The Laboratory also was concerned with the aerodynamic behavior of the Jupiter-C to assure a stable, well-controlled flight. The aerodynamic heating problem was still another of its responsibilities.

Assuring the proper guidance of

the vehicle was the function of the Agency's GUIDANCE AND CONTROL LABORATORY. Years of research—and gradual evolution—have gone into development of the inertial guidance system that helped place the satellite into its long-lived orbit.

Working with Guidance and Control, the RESEARCH PROJECTS LABORATORY studied effects of the earth's magnetic field on the spin of Explorer. Six ABMA Labs cooperated in the development of a complex system to determine the moment of ignition of the second stage, design of an apex timer, and operation of the apex signal system during the launching. Arrangements on scientific instrumentation and tracking were made with Vanguard Project personnel at the Naval Research Laboratory and the Satellite Instrumentation Panel of the IGY National Committee.

The FABRICATION LABORATORY at ABMA developed all manufacturing methods and tooling for the special lightweight and lengthened ballistic shell, and for the upper stages spin launcher. The Laboratory fabricated most of the missile hardware, including such components as the container section, instrument compartment and lightweight air rudders. It performed the pre-assembly operation for static firing, then the final assembly and alignment. It also fabricated and installed the electrical harnesses and network.

Among its contributions the SYSTEMS SUPPORT EQUIPMENT LABORATORY developed a means of reducing the number of cables inside the Jupiter-C, thus considerably reducing weight. The Laboratory also developed the mobile launcher which supported the rocket, and all ground firing accessories such as electrical control and checkout equipment.

The TEST LABORATORY performed a variety of tests on the vehicle's main and upper stages. The missile used for the Explorer I launching had been placed on the shelf after the successful conclusion of the re-entry experiments. After the satellite mission was assigned, certain replacements and renewed testing of the main stage were necessary.

The last stage of work on the booster rocket at Huntsville was the functional testing of all systems and sub-systems by the SYSTEMS ANALYSIS AND RELIABILITY LABORATORY. This testing culminated in a simulated flight during which all components performed in accordance with predicted flight functions. Analysis of the data thus generated determined that the vehicle was ready for air shipment to Cape Canaveral.

While much of the special fabrication and testing was in progress, the COMPUTATION LABORATORY was working with the Research Projects Lab and Aeroballistics Lab in the determination of orbit injection conditions. The Computation Lab also conducted a minimal orbit calculation for use in temperature and altitude studies. Programs designed to lead to quick and accurate orbit calculations were prepared.

AT THE Jet Propulsion Laboratory, scientific and technical personnel were at work on the construction of the upper stages, the satellite shell, and the packaging of the scientific experiments.

JPL was responsible for the satellite payload and its instrumentation; for the development, construction and operation of certain microlock ground stations which receive and record telemetering signals from the satellite; and for design, construction and operation of the solid propellant units.

The designers paid particular attention to heat control. The metal surface of the satellite shell was striped with a flame-sprayed aluminum oxide coating, which covered 25 per cent of the total surface. The remaining surface was sandblasted to give a dull, satiny finish.

This combination of aluminum oxide and sandblasted stainless steel was chosen by JPL and ABMA to give the correct ratios between the absorptivity to solar and infrared radiation. This controls the average temperature of the satellite and its electronic components.

INSTRUMENTATION

EXPERIMENTS installed aboard the 80-inch, 29.87-pound Explorer I included:

1. A Gieger-Mueller cosmic ray counting tube and associated circuitry for the counting of primary cosmic radiation. This apparatus was designed and built by Dr. James A. Van Allen of the State University of Iowa, and was initially prepared for Project Vanguard. JPL repackaged the experiment to meet the cylindrical requirements of the Explorer configuration.

2. Two micrometeorite detector experiments developed at the Air Force Cambridge Research Center by Dr. Edward Manring and Maurice Dubin. One of these was a set of 12 wire grids mounted as a parallel resistance network on the aft end of the fourth stage rocket motor. Collision with micrometeorites would erode or fracture the grid, and variance in electrical resistance would denote the change. The second such experiment was a microphone to record impacts of micrometeorites upon the exterior.

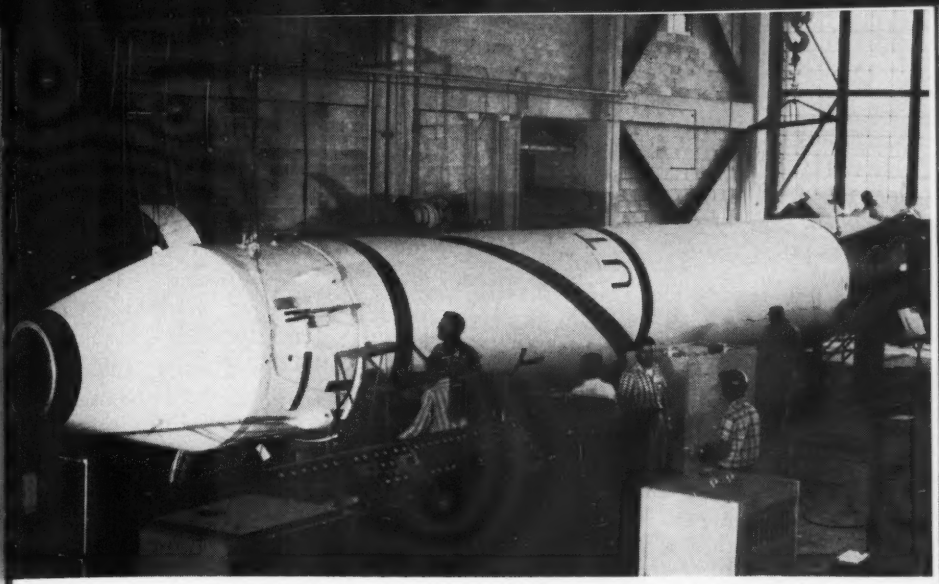
3. Four temperature gauges which read the temperature at three different locations on the outer shell of the satellite and at one location in its interior. These instruments were prepared by JPL.

Data collected by these three experiments would be transmitted to ground receiving stations by two radio beacons.

WHEN the booster left the Missile Agency and the spin launcher and satellite were shipped to Florida from JPL, almost everything humanly possible to assure success had been accomplished. Then came the final series of checks performed at Cape Canaveral jointly by ABMA's Missile Firing Laboratory and JPL technicians.

The power plant and propulsion systems, the pneumatic systems and other functioning assemblies received final scrutiny. The booster, spin launcher and high-speed clusters were assembled on site, employing a specially adapted service tower. Calibration tests of on-missile measuring devices were run off to insure accurate, telemetered data for pre-flight evaluation and flight performance.

Seasoned crews who had launched all of the Army's large ballistic missiles aligned the missile in azimuth and vertical positions. They set up the elaborate electronic gear which would track



Following exhaustive checkout in an Army hangar at Cape Canaveral, this Jupiter C was reassembled prior to launching Explorer III.

the missile for immediate presentation of velocity and position, recording this information on film, tape and oscillographs for later study.

Many other complex preparations were completed. 29 January, the launching date selected weeks before, arrived. That morning weather reports indicated a maximum jet stream velocity out of the west at 170 miles per hour at altitudes between 36,000 and 40,000 feet. Chances of success were marginal. As a test vehicle, the Jupiter-C was not designed to withstand the abnormal stresses which would not interfere with ballistic missiles such as the Jupiter.

The shoot was postponed 24 hours. Next day the wind velocity had increased to 205 miles per hour, making the launching an even greater risk. By early the next day, 31 January, wind velocity had dropped to a maximum of 157 miles per hour at 7.8 miles altitude, which was deemed tolerable. The wind continued to drop. The order was given to proceed.

INTO ORBIT

WHEN "Firing Command!" rang out in the tense blockhouse, the missile roared into life and lifted majestically into space. It rose vertically for eight seconds and then began to tilt into its trajectory. Propelling the giant was about 75,000 pounds of thrust. The powered stage of booster flight lasted 150 seconds. Explosive bolts separated the spent booster from the nose section, and the latter started to coast upward with the spin launcher assembly attached to its tip and rotating at 750 rpm.

The assembly coasted for 250 seconds. During this period the top unit was subjected to spatial attitude control by means of a special system developed by Army missile engineers, to establish the proper angle for injection into orbit.

Just as the assembly reached the top of its arc, 225 miles above the earth, a radio signal, flashed from the Army hangar at the Cape, ignited the second stage. The eleven scaled-down Sergeant missile motors burned for 6½ seconds, in-

creasing the velocity. The third stage of three motors was set off and burned for another 6½ seconds. The final stage of one motor was then ignited and pushed the projectile beyond the orbital speed of 18,000 miles per hour.

The job was done. It was necessary to await confirmation, and it was a harrowing wait, for the Army was traveling untrodden paths. But the answer, the affirmative answer, did come—and there was great joy—and relief.

SCIENTIFIC FINDINGS

EXPLORER I was placed in orbit at a velocity of about 18,500 miles per hour. Its minimum distance from the earth was about 224 miles, with the maximum at 1,573. Lifetime predictions vary from five to ten years.

A great deal of extremely valuable information has been gained from Explorer I's scientific apparatus. The scientific experiments and the radio beacons have done their work well. The high-power transmitter, whose batteries were expected to last about two weeks, ceased transmission about twelve days after the launch. About ten days later it came back on the air but had an insufficiently clear signal to permit interpretation of the data it was supposed to transmit. It continued to send generally weak signals until about one month after launching.

At mid-May the low-power transmitter was still functioning. It was fully meeting its lifetime expectancy of two to three months.

EXPLORER I confirmed man's ability to control temperature within an artificial satellite. JPL scientists have been assured by results that their technique for temperature control is adequate for the successful operation of sensitive electronic equipment. Internal temperature was maintained between 32 and 104 degrees Fahrenheit—well inside the tolerance needed to protect instrumentation from heat or cold failure. Outside temperature, measured at the shell, fluctuated between 14 and 167 degrees Fahrenheit. Inside temperature, of course, is easily within the range of human survival.

JPL scientists pointed out in their initial report of findings that this experiment was designed only to study the problem of instrument environment in a very small enclosure. Success of this simple device indicated that with more elaborate techniques the inner temperature of a larger space vehicle could easily be controlled within a much narrower range.

IN THE cosmic ray experiment, the Explorer revealed that cosmic radiation at extreme altitudes was far greater than had been anticipated. The satellite's reports from the far reaches of its orbit revealed unidentified radiation so intense it overwhelmed the cosmic ray counter. At altitudes beyond 1,000 miles the counts of particle pulses per second soared to ranges hundreds of times greater than had been expected.

While Explorer I counts ran the expected 30 to 40 per second 200 to 300 miles above Southern California, the counts climbed to more than 35,000 per second at the highest altitudes above South America and adjoining waters.

It is assumed that the high rate was produced by protons, or that it was due to X-rays produced in the satellite shell by electrons. In either case it is believed that the particles come from the sun, whereas cosmic rays are believed to hurtle toward earth mostly from interstellar space far beyond the sun.

The results of the experiment are totally inconclusive. Accepted at face value, and assuming that the intense radiation exists at all levels above the earth's atmosphere, this could mean that it would be unsafe for man to remain in space for more than five hours without special protection from dangerous quantities of the invisible light known as X-radiation.

It is also possible that the potentially dangerous radiation is confined to a spatial zone only a few hundred or a thousand miles deep. (It was to measure and define the nature and extent of this high intensity corpuscular radiation that Explorer IV was later launched. Designed by the State University of Iowa Physics Department, the experiment is designed to reveal whether the high corpuscular radiation emanates from the sun or from interstellar space far beyond the sun.)

IN THE third area of Explorer I instrumention, a preliminary review of the data received on the condition of the wire grids indicates that one or two of these grids were fractured during the launching of the last stage. Since that time, no additional fractures have been observed.

The impact microphone whose telemetered signals were carried on the high-power transmitter operated successfully throughout the lifetime of that transmitter. Several records show a change in frequency of this telemetering channel, indicating impact of a small particle on the shell of the satellite.

VISUAL and photographic observations of Explorer I are contributing to still another area of science. The Smithsonian Astrophysical Observatory's Moonwatch teams reported more than 100 sightings of the satellite during its first three months of orbiting. The 80-inch projectile has been photographed many times, and these pictures have been used to compute and predict more precise orbital data for other satellites; they are now being analyzed to provide information about the earth's equatorial bulge, and anomalies in the earth's gravity.

COSMIC RAY STUDIES

EXPLORER III gathered and transmitted three types of information: temperature, cosmic dust erosion, and the intensity of cosmic radiation. The main part of the instrument package is the cosmic ray experiment, which was designed by Dr. James A. Van Allen of the State University of Iowa. Studies based on this experiment are expected to lend further understanding to the first Explorer's puzzling discoveries on radiation.

There were essentially no differences in the carrier vehicle or the launching methods of the satellites. There were, however, several significant changes in the instrumentation in Explorer III.

A major change was the addition of a miniature tape recorder, developed by the State University of

Iowa, which collected and "froze" on tape the data on cosmic radiation encountered during the total orbit. Upon signal from a ground station, this information was played back; then the tape was automatically erased and reset.

Scientists consider information gained from this memory system a marked improvement over that of Explorer I. The first satellite dispatched data continuously; but its information was received only in areas of the orbital band that had ground stations. Many "blanks" occurred, particularly when Explorer I was over large bodies of water. Explorer III, however, sent out cosmic radiation information representative of the total orbit, thus providing for the first time a comprehensive survey of total cosmic ray intensity above the earth with respect to both time and position.

The addition of the tape recorder necessitated a change in the operation of the radio transmitters. In Explorer I, both of them had operated continuously. Explorer III's lower power transmitter likewise functioned continuously. But its other transmitter passed on the data gathered by the tape recorder, and only operated a few seconds during each orbit—whenever the playback signal was given from a ground station. A small radio receiver was added to receive the playback command.

The higher power AM transmitter radiated approximately 60 milliwatts of power and broadcast at a frequency of 108.03 megacycles. It transmitted only cosmic radiation information.

The low power FM beacon, with 10 milliwatts of power on a frequency of 108.00 megacycles, also transmitted cosmic ray data on one channel. Its other three channels were devoted to internal and external temperatures, and micrometeorite erosion.

Minor changes were made in the temperature and micrometeorite experiments. The number of temperature sensors was reduced from four to two, one each giving external and internal readings. For measuring meteoric particles, an impact microphone carried in Explorer I was eliminated in the second flight. However, Explorer III, like the earlier one, carried an erosion gage on the exterior of the instrument section.

Explorer IV carries 18.26 pounds of instruments—all devoted to radiation studies.

STILL other satellites, larger and more advanced, will follow these Explorers and contribute an infinite wealth of knowledge to space-searching men. Unmanned and manned vehicles in space will provide new concepts of peaceful as well as military use. As in all new types of endeavor, many applications will be derived which cannot be foretold. But already many potential benefits are apparent. The platform in space, the world-wide communications relay stations far out and untroubled, the perfect weather forecast and the possibility of weather control, and finally, the unfolding knowledge of the universe beyond the stars—all challenge man to continue his exploration.

Another success—

Jupiter IRBM Nose Cone Recovered Intact

BLINKING signal lights amid a vast expanse of ocean—a patch of yellow and green marking dye containing shark repellant—a five-foot orange and blue balloon—all combined to lead Navy ships and frogmen to the recovery of another full size nose cone of an Army Jupiter Intermediate Range Ballistic Missile.

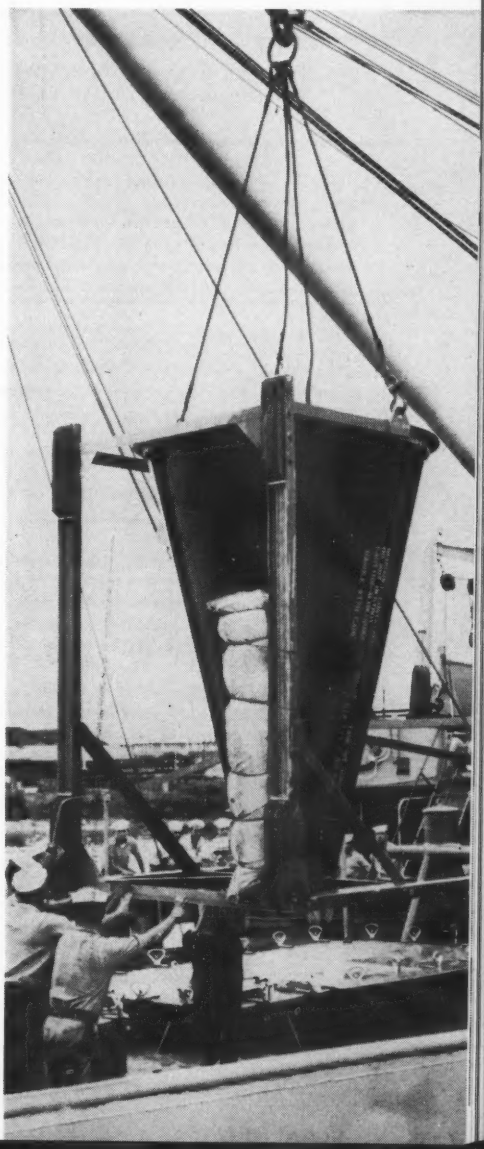
This was the second recovery of a full size nose cone, in addition to that of a scale model in August 1957. First recovery was 18 May; the second 17 July 1958, following a successful launch and flight through outer space to impact accurately in the predetermined target area. Both missiles were launched from the Air Force-operated Atlantic Missile Range, Cape Canaveral, Florida.

The three recoveries underscore the fact that Army missilemen have found a satisfactory solution to the warhead protection problem. The cone affords protection against aerodynamic heating as the object reenters the atmosphere at a speed of some 10,000 miles an hour. Without such protection, heat generated by friction with the air would melt the cone and cause the warhead to be destroyed short of the target.

THE cone was designed and developed by the Army Ballistic Missile Agency and one of its contractors, Cincinnati Testing and Research Laboratories. Recovery gear was developed by Cook Electric Company, Evanston, Illinois.

Recovery was effected by the U. S. Navy using three destroyer-escort ships and a smaller ship, with two P2V aircraft. The ships were in position before the firing, with planes hovering overhead to observe the descent and help guide the smaller ship.

As the cone hit the water air bottles inside it inflated a five-foot orange and blue balloon which carried radio transmitter and flashing light aloft; dye containing shark repellant also spread over the water to help pinpoint the location. Navy frogmen, careful not to antagonize ever-present sharks, attached the cone to a buoy and it was hoisted aboard the auxiliary submarine rescue ship. The special hoisting gear was designed by Army Ordnance Missile Command engineers.



Shortly after recovery, the Jupiter nose cone is encased in steel container aboard a Navy vessel.

SPACE PRIMER

REFLECTING the Nation's ever widening interest in the new frontiers of space science and technology, the President's Science Advisory Committee, Dr. James R. Killian, Jr., Chairman, last spring published a brief "Introduction to Outer Space" for the non-technical reader. "This statement," President Eisenhower declared, "makes clear the opportunities which a developing space technology can provide to extend man's knowledge of the earth, the solar system, and the universe. . . . Every person has the opportunity to share through understanding in the adventures which lie ahead."

Excerpts from the Space Primer appear on these two pages.

TO LAND instrument carriers on Mars and Venus will be easier, in one respect, than achieving a "soft" landing on the moon. The reason is that both planets have atmospheres than can be used to cushion the final approach. These atmospheres might also be used to support balloons equipped to carry out both meteorological soundings and a general photo survey of surface features.

ROCKET engineers rate rockets not in horsepower, but in thrust. Thrust is just another name for push, and it is expressed in pounds of force. The rocket gets its thrust or push by exhausting material backward. It is this thrust that lifts the rocket off the earth and accelerates it, making it move faster and faster.

IF WE WANT to send up not a satellite but a device that will reach the moon, we need a larger rocket relative to its payload in order that the final stage can be accelerated to about 25,000 mph. This speed, called the "escape velocity," is the speed with which a projectile must be thrown to escape altogether from the gravitational pull of the earth. If a rocket fired at the moon is to use as little fuel as possible, it must attain the escape velocity very near the beginning of its trip. After this peak speed is reached, the rocket will be gradually slowed down by the earth's pull, but it will still move fast enough to reach the moon in two or three days.

THERE may well be important military applications for space vehicles which we cannot now foresee, and developments in space technology which open up quite novel possibilities. The history of science and technology reminds us sharply of the limitations of our vision. Our road to future strength is the achievement of scientific insight and technical skill by vigorous participation in these new explorations. In this setting, our appropriate military strength will grow naturally and surely.

WHY SATELLITES STAY UP

WE all know that the harder you throw a stone the farther it will travel before falling to earth. If you could imagine your strength so fantastically multiplied that you could throw a stone at a speed of 15,000 mph, it would travel a great distance. It would, in fact, easily cross the Atlantic Ocean before the earth's gravity pulled it down. Now imagine being able to throw the stone just a little faster, say about 18,000 mph, what would happen then?

The stone would again cross the ocean, but this time it would travel much farther than it did before. It would travel so far that it would overshoot the earth, so to speak, and keep falling until it was back where it started. Since in this imaginary example there is no atmospheric resistance to slow the stone down, it would still be travelling at its original speed, 18,000 mph, when it had got back to its starting point. So around the earth it goes again. From the stone's point of view, it is continuously falling, except that its very slight downward arc exactly matches the curvature of the earth, and so it stays aloft—or as the scientist would say, "in orbit"—indefinitely.

IF A feather were released from a ten-ton satellite, the two would stay together, following the same path in the airless void. There is, however, a slight vestige of atmosphere even a few hundred miles above the earth, and its resistance will cause the feather to spiral inward toward the earth sooner than the satellite. It is atmospheric resistance, however slight, that has set limits on the life of all satellites launched to date.

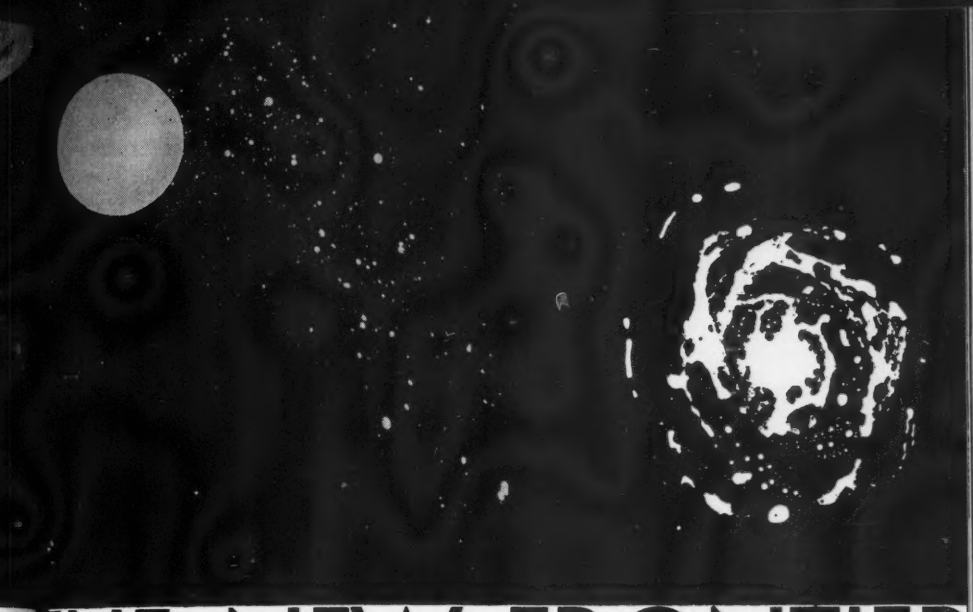
TO LAUNCH some of the present satellites has required rockets weighing up to 1,000 times the weight of the satellite itself. But it will be possible to reduce takeoff weights until they are only 50 to 100 times that of the satellite. The rocket's high ratio of gross weight to payload follows from a fundamental limitation in the exhaust velocities that can be achieved by chemical propellants.

IF SPACE is to be used for military purposes, we must be prepared to use space to defend ourselves.

MUCH that scientists wish to learn from satellites and space voyages into the solar system can be gathered by instruments and transmitted back to earth. This transmission, it turns out, is relatively easy with today's rugged and tiny electronic equipment. For example, a transmitter with a power of just one or two watts can easily radio information from the moon to the earth. And messages from Mars, on the average some 50 milion to 100 milion miles away at the time the rocket would arrive, can be transmitted to earth with less power than that used by most commercial broadcasting stations. In some ways, indeed, it appears that it will be easier to send a clear radio message between Mars and earth than between New York and Tokyo.

IT HAS BEEN the military quest for ultra long-range rockets that has provided man with new machinery so powerful that it can readily put satellites in orbit, and, before long, send instruments out to explore the moon and nearby planets. In this way, what was at first a purely military enterprise has opened up an exciting era of exploration that few men, even a decade ago, dreamed would come in this century.

With radar and Explorers probing the nature of spa
the Army penetra



THE NEW FRONTIER

Brigadier General Earle F. Cook

TODAY'S ARMY has a vital interest in the new dimension that has been added to military science—the exploration and use of outer space. The reason: this new dimension enlarges the potential areas of defense and offense beyond all past extensions in the history of warfare.

The efforts of leading Army scientists are spearheaded at three aspects of this new frontier. The first aims at new knowledge of the new medium itself; the second, at propulsion of a vehicle through it; and the third, at communication with the vehicle irrespective of position and distance. Through the latter link, vital information is returned from space about the medium itself; and, in the other direction, a channel is created with the potential of command control

BRIGADIER GENERAL EARLE F. COOK is Chief, Research and Development Division, Office of the Chief Signal Officer, Department of the Army.

over what the space vehicle does.

The Army's first successful breakthrough into space to learn its make-up preceded the physical launching of a satellite by some twelve years when in 1946 the Army Signal Corps broke through the ionosphere to make man's first radar contact with the moon. Thereafter, earth-moon contacts from the U. S. Army Signal Corps Research and Engineering Laboratories at Fort Monmouth, New Jersey, have continued almost uninterruptedly. Invaluable scientific data have been recorded that can be applied virtually anywhere in the 480,000 miles traversed in the round-trip.

As this new dimension of outer space becomes an employed reality extending the areas of defense and offense, new additions to military nomenclature will come into common use. In the past, these have been largely in the province of the physical scientist and electronics engineer who have been concerned with its electromagnetic penetration and use.

SPACE STRATA

PERHAPS the most straightforward way to visualize this new outerspace frontier is to view it by vertical structure as if standing on the ground looking directly upward. In such vertical sequence, the earth's atmosphere has four progressive layers.

First is its lowest level, or *troposphere*. Here are cloud formations, convection, condensation, and thermal air movements. On ascending, the temperature drops at the rate of about 13° Fahrenheit per mile. In the middle latitudes this drop continues up to some 6½ miles; then comes a region of constant temperature, or isothermic area.

The troposphere today plays a very important role as a radio transmission medium. Through "tropospheric scatter", signals are returned to earth to provide highly reliable communication on frequencies otherwise useless for the considerable distances covered. Thus one phase of tropospheric re-

Bouncing Signals Off the Moon

THE launching of Explorer I the last day of last January was the most thrilling achievement in the recent scientific history of our country. But this was not the Army's first probing into space. In January 1946 the Army Signal Corps broke through the ionosphere to make man's first radar contact with the moon. From then until now, contacts with the moon by the Army Signal Research and Engineering Laboratories at Fort Monmouth, New Jersey, have continued almost uninterrupted—a total of approximately 1,000. As a result of bouncing these signals off the earth's big satellite, many scientific facts relating to the 480,000-mile round trip are now known.

ONE of many possible illustrations of the value of these radar contacts is the discovery of hitherto unknown facts about the troposphere, which plays such an important role as a radio transmission medium. Through "tropospheric scatter" signals are returned to earth to provide highly reliable communication on frequencies otherwise useless for the considerable distances covered. This facet of research has already paid big dividends by opening whole series of channels for special military and commercial purposes.

search has already paid major dividends by opening a whole series of channels for special military and commercial purposes.

Directly overlaying this tropospheric medium is the *stratosphere.* Here temperature is constant until a height of about 15 miles; thereafter the temperature rises through absorption by an ozone layer of short-wavelength ultraviolet radiation from the sun. This ozone layer extends from about six to some 27 miles above mean sea level. As we proceed upward beyond this, the temperature drops again at about 48 miles, the height of noctilucent clouds—*i.e.,* those which appear luminescent at night, and presumably formed of ice crystals.

Proceeding upward, we enter the lower reaches of the *ionosphere,* the reflecting mirror for our long-distance terrestrial and intercontinental radio transmission. Here are found layers with varying degrees of ionization (that is, containing electrons torn from their parent atoms or molecules and remaining free in large numbers). One layer, the D-region, lying between 36 to 48 miles above the earth, is weakly ionized *(i.e.,* with relatively few free electrons). These electrons are greatly increased during periods of solar storms, causing disturbance to radio waves normally reflected to earth by higher levels. The upshot is disruption of our otherwise usable long-distance circuits.

ABOVE the D-layer is the important E-layer, ranging from some 54 to 90 miles, with maximum ionization at about 72 miles. Interestingly, this E-ionization is solely a daylight phenomenon, shown by its

Engineers and craftsmen turned the theory of a weather observation satellite into this gleaming reality at the Army Signal Research and Development Laboratory.

virtual disappearance during a total solar eclipse. Overlaying it is the F-layer starting at some 90 miles and extending to an indefinite height. By sounding the ionosphere (with radar-like sounders) two sub-layers, F_1 and F_2, have been located at some 90 and 150 miles respectively. F_1 either disappears or merges with F_2 at night.

Still proceeding upward, we enter the *exosphere* whose base, it is computed, lies approximately 300 miles above the earth. At this point atmospheric density has become so low that atomic or molecular collision reaches insignificance. Thus the distance a molecule can travel without collision is now in the order of hundreds of feet, whereas at sea level this free-travel distance is a microscopic fraction of an inch. This virtual void, however, is readily traversed by a radio wave—a finding first proved by the Army Signal Corps' radar which went straight through to the moon and back, and confirmed more recently by satellite transmitters successfully orbiting within the exosphere.

Beyond the ionosphere and exosphere, we enter the *interplanetary medium*, also traversed by the Signal Corps earth-to-moon radar. Here are found varying magnetic fields and changing amounts of tenuous gases or particle streams, as well as comparatively low-energy cosmic rays from the sun. Contrary to popular belief, the principal source of cosmic rays bombarding the earth appears to be, not the sun, but far-distant stars and supernovae and their remnants.

SPACE HAZARDS

LOOKING to the future, what are some of the presently discernible hazards to manned travel in

space? Besides the interplanetary hazard of cosmic rays, debris of various sorts is of course present, for the most part moving about the sun. This space garbage varies in size from mere micrograins of sand to monolithic masses several miles across. When pieces several inches across enter this atmosphere, they become incandescent meteors readily seen at night. Radar of course detects them day or night, and their ionized trails are now under study and experiment as short-time but highly effective reflecting media for terrestrial point-to-point radio links.

On the premise that one end-destination of interspace travel will be a planet itself, we are naturally vitally interested in *planetary atmosphere.* Not only must our vehicle enter and be controllable in it; if the vehicle is manned, the presence or lack of planetary atmosphere will be an important factor in determining habitability.

At present, the existence or lack of an atmosphere on any planet or satellite is deduced by spectroscopic evidence, by refraction, or by cloud formations. This is aided by other methods, such as light scattering caused by any existing atmosphere.

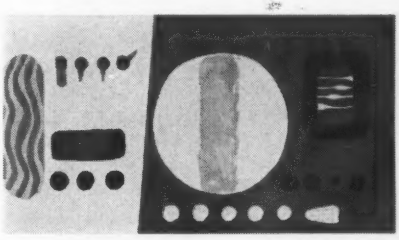
Though the moon itself has undergone intensive probing by Army radar and by a dozen other exploratory sciences, much is still unknown about it. Recent radiotelescope observations point to an electron density increase at the moon's surface exceeding that of outer space. This could indicate a residual atmosphere of heavy gases, or simply be the result of accretion of a surface photoelectric effect. At any rate, repeated spectroscopic observations have detected nothing but the reflected solar spectrum, leading to the conclusion that the moon has virtually no atmosphere. Similarly, spectroscopy points toward the same conclusion for Mercury.

This virtual void however is not necessarily true of other planets. Repeated observations indicate that Venus has an atmosphere of carbon dioxide, plus traces of water vapor and oxygen, while a spectroscopic look at Mars shows its atmosphere as largely nitrogen, also with traces of oxygen and water vapor.

Paradoxically, the large outer-planets present simpler analysis problems than do Mars and Venus. Spectroscopic observations are easier because absorption bands of these very large bodies occur with considerable intensity, overriding interfering lines of earth origin.

SIGNALING IN SPACE

AS military effort goes forward toward space knowledge and propulsion of a vehicle into or through it, the Army Signal Corps is exploring the vital signal and command-control link between the earth and vehicles in space. Thus when propulsion is developed for a moon-vehicle, for example, the needed signal system may be equally ready —or at least such would be the ideal phasing of these complementary developments.



An Aerobee research rocket takes off from launching enclosure at Fort Churchill, Canada, to explore North Wind at its source.

The Army's extensive experience with moon radar and more recent satellite tests leads to a series of interesting conclusions. For example, we know by computation approximately what will be required aboard a moon vehicle to send signals back to earth, say, while landing. Using the same microlock receiver system on earth that has proved so effective for the Explorer satellites, not much more than 7-milliwatts would be needed aboard the moon vehicle for the same performance, 78-watts aboard a vehicle on Venus, and some 270-watts when circling in for a landing on Mars.

All things considered, this capability is not too difficult to achieve, and is constructionally aided by recent Army advances in micro-miniaturized parts which provide high performance in a compact package. A vehicle with the thrust to reach a distant planet in the first place could probably carry it readily.

Other interesting facts are already known, for instance, about two-way telephonic conversations with the moon and other planets. When we get there, we can converse with earth by radio, but the phrasing must be differently paced than over our earth-bound circuits. Say "Hello Moon, this is Earth," and the delayed response won't necessarily mean inattention by the listener or a poor circuit. Voice sounds will simply take appreciable time to cover the intervening distance, even by two-way, lightning-fast radio.

The same phenomenon will be much more evident on Venus and

Space Sentry radar dominates scene, with 50-foot Diana radar in background at Fort Monmouth, New Jersey.

Mars circuits. Our voice will take 2½ minutes to reach the first planet, and 4½ minutes for the second. Thus a new telephone technique will be in order. The speaker would deliver his message in an uninterrupted burst for a few minutes, then wait an appropriate time for the answer from outerspace. Even if both parties spoke at once by prearrangement, there would still be no rude interruption, the two voices simply passing each other en route in space.

Among the problems which can be deduced in advance, consider that of voice versus picture transmission from the moon. Assuming that our crew has landed on the moon, the 7-milliwatt transmitter will serve for voice transmission. But suppose the crew needs to send back a televised picture of a situation for scientific or tactical purposes. Here we run into a serious technical block. For a satisfactory picture as seen on your home TV-set (and using the same information bandwidth), more than *two hundred thousand watts* would be needed in our moon transmitter to flash pictures back to earth. By 1958 standards, this represents massive equipment far more sizable than that of large commercial fixed stations weighing tons.

NEW DIMENSIONS— NEW CONCEPTS

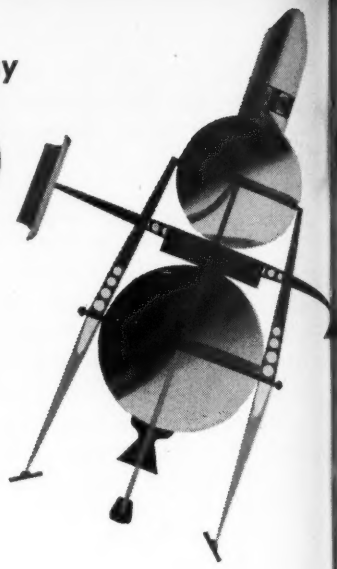
WITH advances in propulsion and explorations of outer space bodies, undoubtedly there will be need to televise back pictures of terrain, situations, or events as they occur. What may be needed therefore is a wholly new concept of conveying mass data and pictures across space — perhaps a system with little or no relationship to our present electromagnetic usages. Such a development would have direct military application for terrestrial use, solving at least a dozen present problems of conveying mass data over extended distance for tactical employment. Thus one breakthrough initiated and aimed at the exploration of outerspace could well revolutionize contemporary military tactics on earth.

The opening of outer space as a new dimension of military science calls for the free-thinking creativeness of the Nation's best brains, in turn supported by the greatest array of facts that can be assembled.

The evidence is clear-cut and convincing: the battles of the future will not be won on the battlefield unless *beforehand* they are theoretically won on the blackboard. This is the unique end-target of military research and development. In this contest, the rapier is the slide-rule, and the field-piece is the equation on the back of a physicist's scratchpad.

Where scientific facts rival fantasy

BEYOND



GRAVITY

the physical aspects of space flight

INTERPLANETARY travel logically involves three stages in the manned exploration of space—first, passage through the earth's atmosphere; second, the vacuum beyond the sensible atmosphere; and finally, the atmosphere of the other planet.

Such travel might be compared to an overseas journey in a jet aircraft—the relatively rough take-off, the smooth passage through high altitude air and, finally, landing.

As envisaged by Army Ballistic Missile Agency developers, the first step in interplanetary travel will be a rocket-powered trip from earth's surface to an orbital space station at 1,000 miles altitude *(See "Manned Platform in Space," page 32).*

"Commuter" vehicles, earth-to-satellite, will be propelled by chemical fuels. Not only must they be able to overcome gravity and atmospheric drag, but they must also attain a velocity equal to that of the satellite, in the order of 18,000 miles per hour.

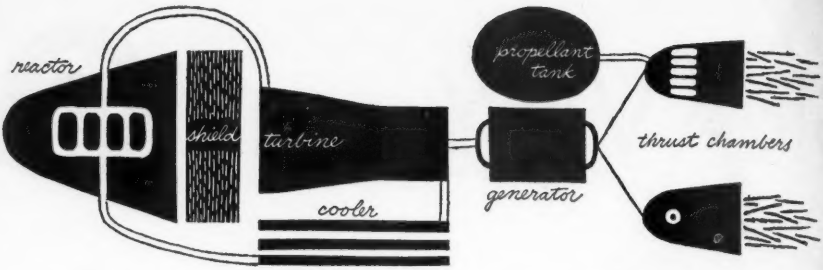
While relatively short, the first stage of the journey is the most expensive. It requires about 50 pounds of missile to transport one pound of material to an altitude of 1,000 miles. Chemical propulsion is considered superior for this application because it furnishes a great amount of thrust quickly.

Technicians operating on the satellite station would assemble the deep space ship, which need not be streamlined since it would function only in almost perfect vacuum. Because of the mild forces it will encounter, the ship will be lightly built. However, it must contain a system to provide artificial atmosphere for its human passengers who will occupy sealed quarters for a long time.

A round trip to Mars, for instance, might require from six months to three years depending upon the type of propulsion employed. The travel time will lessen as technology improves.

Dr. Ernst Stuhlinger of the Missile Agency has proposed ionic propulsion for deep space ventures—a type of propulsion which would be most efficient on the longer journeys, to planets beyond Mars. With this type of power, the ship would accelerate slowly but could operate for amazingly long periods.

Prof. Herman Oberth, consultant in the Missile Agency, suggests another type of propulsion utilizing the condensation principle. Known as an electric-core ship, it would have a shorter range than the ionic system but longer range than chemical rockets. A round



Artist's Conception of an Ion Propulsion Motor.

trip to Mars would require only six months if fuel for the return can be found on the planet. A conventional, chemically-powered ship would require three years.

Fuel weight also limits the use of chemical rockets. For a round trip to Mars from an earth satellite, a 3500-ton vehicle would be needed to transport 25 tons of payload. The ionic ship would require two years for a round trip for it would reach Mars before attaining maximum velocity.

A fourth type propulsion system has been proposed but the concept is too new for adequate evaluation. This is an electro-magnetic system which derives thrust from the rapid release of ion particles.

NAVIGATING IN SPACE

REGARDLESS of the type ship selected for the second stage of interplanetary travel, the traveler will experience much fewer hazards and less discomfort than his predecessor who sailed uncharted seas centuries ago. The space ship will offer radio and television and many other comforts of daily life.

Departure from a satellite station would be less taxing upon the passenger than the initial leg of his journey from earth. Smoother takeoff would be achieved with either the ionic or electrical propulsion systems and acceleration would be much less.

The deep-space ship would carry a crew, supplies of oxygen, water, food, observation instruments, communication equipment and auxiliary craft for landing and subsisting on another planet. The primary energy source would be a nuclear reactor which would entail shielding—and the reactor must be separated from the crew quarters by not less than 80 yards. Lightness of structural elements would compensate for the huge size of the ship.

The flight path in the second stage of the journey would be unlike that from earth. A space ship

Life Among the Planets

NAVIGATORS in deep space will experience fewer hazards and discomforts than their predecessors who sailed the uncharted seas centuries ago. The deep space ship will have radio, television, observation instruments, communication equipment and auxiliary craft for landing and subsisting on another planet.

Conditions will vary greatly from one planet to another. When the travelers take off for the return trip they will spend a number of days in a gentle spiral away from the planet they have just visited, until they make contact with the orbiting space station from which their journey began.

equipped with the electrical propulsion system follows a spiralling trajectory rather than the elliptical path typical of chemical rockets. Its distance from the satellite would increase slowly. After two years it would be only 20 miles above the satellite.

On the other hand, an ionic ship at the end of 100 days would have spiralled a distance of 100,000 miles above earth and would have completed hundreds of revolutions around the earth. It would then be about halfway to the Moon. A few days later its distance from earth would be so great that the influence of the gravitational field of the earth would be negligible.

SPACE navigation offers no insurmountable problem. Automatic star trackers will measure and record directions to celestial bodies with respect to the direction to fixed stars. The relative position of sun, stars and planet would be accurately known. Acceleration or deceleration by the propulsion system would immediately correct for any deviation.

In space navigation it is practicable to leave all earth-bound concepts behind. The navigator now assumes the point of view of the astronomer. The curve known as ellipse is the ruling geometrical figure. Planets revolve around the sun in elliptical paths; moons revolve around the planets in elliptical paths.

When the ship approaches a planet where landing is planned, the landing trajectory will also be an ellipse tangent to the planet's ellipse. It will be necessary to maneuver the ship by acceleration into a spiral around the planet; otherwise it would crash on the planet or pass it by.

LANDING AND RETURN

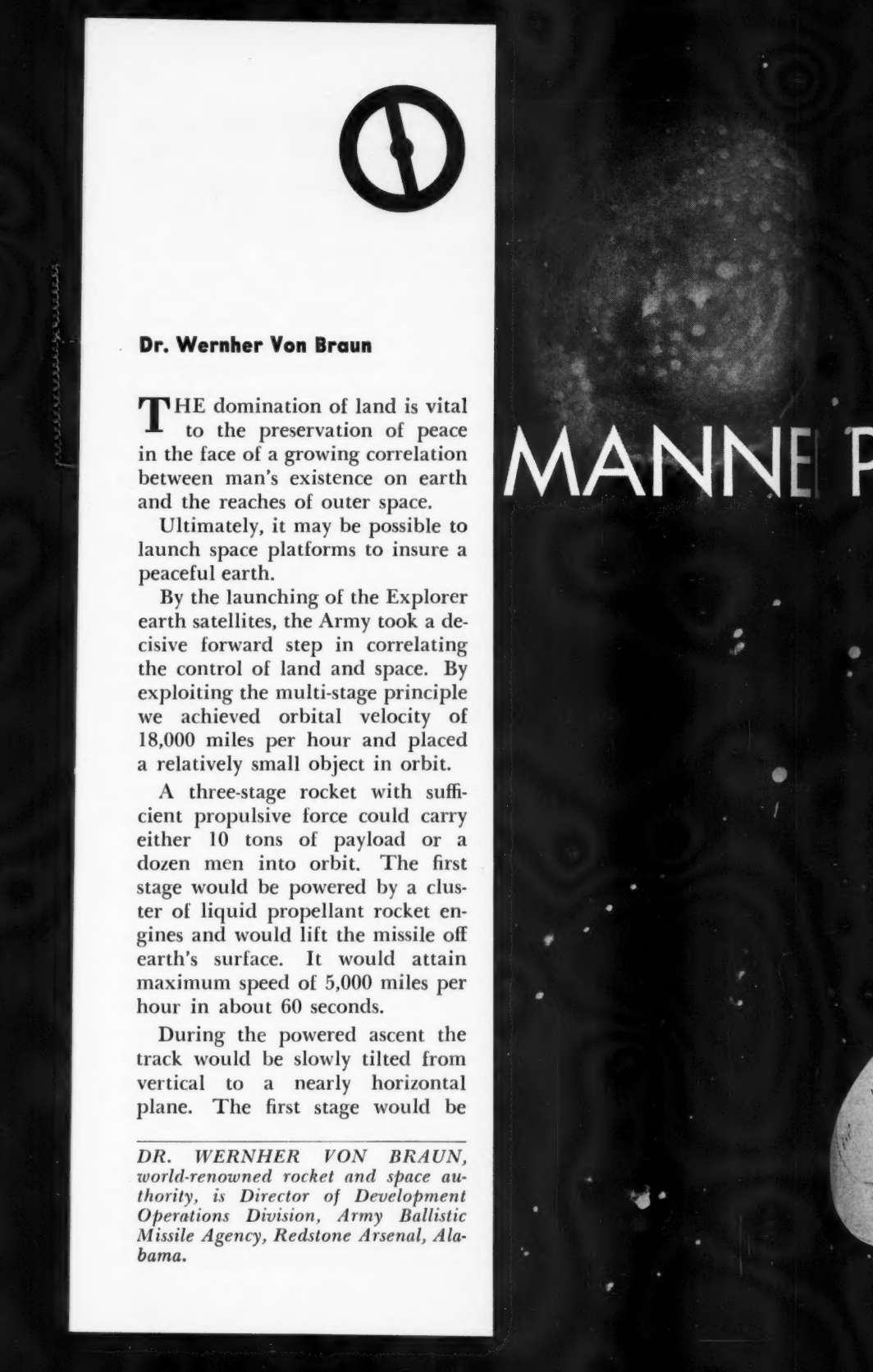
THE final descent through the planet's atmosphere requires a third stage vehicle, probably a winged landing craft powered by rockets which can propel it back to the orbiting space ship.

The conditions encountered by the explorer landing on a planet will vary greatly from one planet to another. Although all the planets of the solar system move around the sun in the same direction, they do not move with the same speed. A whirlpool illustrates this phenomena. If the sun were the center of a whirlpool, then the water nearest it would whirl faster than water farther away. So it is with the planets—the nearest rotate much more rapidly than others. They need the higher velocity to prevent the more powerful attraction of the sun from pulling them to it.

The return trip from the planet will be similar to the arrival. When the passengers take off, they will spend a number of days in a gentle spiral away from the planet until they make contact with the orbiting ship waiting their return.

Once aboard the deep space ship, more spiralling would follow until the time to straighten the trajectory on through space and eventual return to the earth satellite from which the journey began.

Here, too, winged vehicles would probably be employed for the comparatively short and speedy return trip to earth's surface. The first men to return will receive a welcome rivalling that accorded the great explorers of the past.



Dr. Wernher Von Braun

THE domination of land is vital to the preservation of peace in the face of a growing correlation between man's existence on earth and the reaches of outer space.

Ultimately, it may be possible to launch space platforms to insure a peaceful earth.

By the launching of the Explorer earth satellites, the Army took a decisive forward step in correlating the control of land and space. By exploiting the multi-stage principle we achieved orbital velocity of 18,000 miles per hour and placed a relatively small object in orbit.

A three-stage rocket with sufficient propulsive force could carry either 10 tons of payload or a dozen men into orbit. The first stage would be powered by a cluster of liquid propellant rocket engines and would lift the missile off earth's surface. It would attain maximum speed of 5,000 miles per hour in about 60 seconds.

During the powered ascent the track would be slowly tilted from vertical to a nearly horizontal plane. The first stage would be

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DR. WERNHER VON BRAUN, world-renowned rocket and space authority, is Director of Development Operations Division, Army Ballistic Missile Agency, Redstone Arsenal, Alabama.

E PLATFORM IN SPACE

jettisoned after burnout and the second stage rockets would add a velocity increment of approximately 9,000 miles per hour. After a total speed of about 14,000 miles per hour had been reached, the second stage would be dropped.

Now the rocket motor of the top stage would take over, forging ahead with initial speed of 14,000 miles per hour until the final orbital speed of 18,000 miles per hour had been reached. This is sufficient to keep the top stage in permanent orbit. A stable orbit requires, of course, that the centrifugal force along the curved orbit cancels the gravitational pull of earth.

During the ascent of such a rocket ship, the crew would undergo high acceleration. This gradually increases as the ship loses weight due to fuel consumption, the thrust remaining constant. First peak of the acceleration curve is reached at the first-stage cut-off and could not be more than 9 g's.

After this peak it would drop to about 1½ g's when the smaller second-stage motors take over. A second peak occurs at cut-off of the second stage; again, this could not be more than 9 g's.

A third peak will be reached at cut-off of the third stage but acceleration will not be as high because this stage carries the payload for the orbit—or it could be an earth-returnable upper stage loaded with propellants for the return flight.

MEN BEYOND GRAVITY

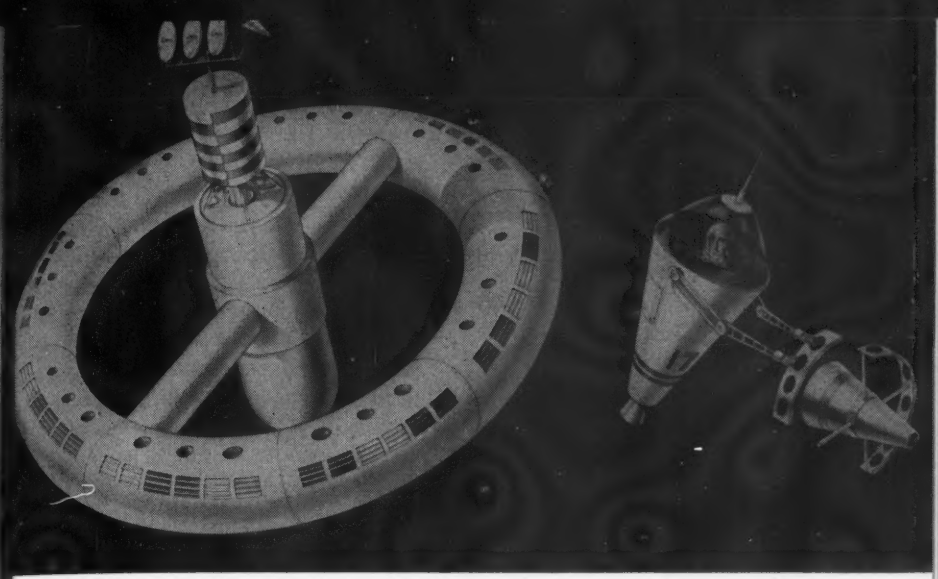
THE crew manning the ship would function as a team under harsh environmental conditions. After experiencing the stress of high acceleration during ascent, the crew must contend with weightlessness. It is frequently assumed that this condition occurs only after a rocket ship leaves the gravitational pull of earth. This is untrue. Weightlessness in a rocket occurs the moment the engines are cut off and the ship coasts freely outside the atmosphere in any trajectory or orbit.

The sensation of weight is actually caused by gravity and also by the floor on which we stand and which prevents us from following the pull of gravity. It requires gravity plus a rigid support to create the condition of weight. As you withdraw support and permit the body to respond to gravity, that body is weightless. The diver jumping off a board is weightless for a second or so until he strikes the water.

Vehicles in Space

AS PROJECTED by Dr. Wernher von Braun, we could have a three-stage rocket with sufficient propulsive force to carry a dozen men into orbit. The ship would go around the earth every two hours. The earth would rotate inside the orbit every 24 hours. So, the orbiting rocket would pass the Equator at a different meridian each time. An observer could see different parts of the earth on each revolution, and within 24 hours he would have opportunity to see every point on earth at least once.

But a manned rocket circling the earth is not the only possibility. As envisioned by Dr. von Braun, a manned, permanent space station could be placed in orbit 1,075 miles up.



"Prefabricated sections for an orbital station . . . could be assembled by operators in pressurized containers . . ."

Flying in a rocket ship which is not powered means simply that every molecule in the body is subjected to the same laws of unpropelled motion through a gravitational field as the molecules of the ship itself. Consequently there can be no differential forces between the human body and the walls of the ship. The crewman would float freely about the cabin.

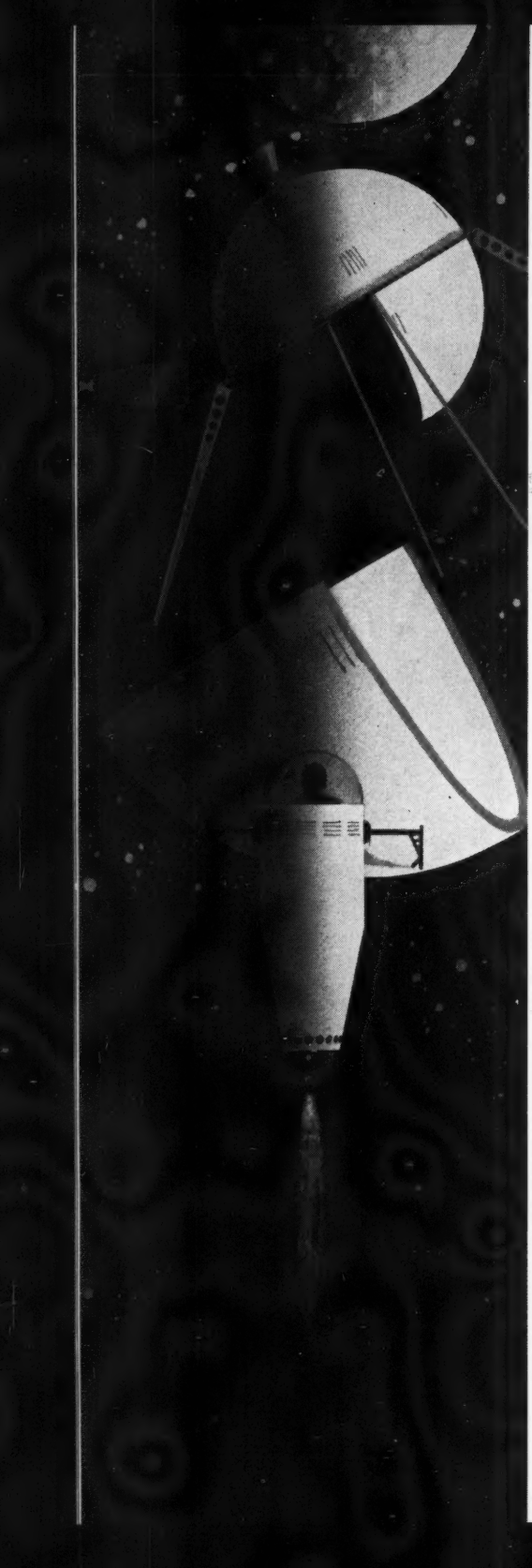
The condition may be simulated. For example, an airplane descending in an inclined dive, and pulling out, passes along a ballistic trajectory. The trajectory is essentially a parabola wherein the aerodynamic drag is compensated with the thrust of the propulsion system. The plane can be guided so that it flies at "zero lift." During the brief period of flight through ballistic trajectory, a weightless condition prevails in the plane's cockpit. Thus, with conventional jet aircraft, weightlessness has been simulated for about 40 seconds.

With advanced modern ballistic missiles, such as the Army Ordnance-developed Jupiter, which travel at much higher speeds and over much longer trajectories, the condition has been extended to many minutes—without passengers so far.

What happens to man in this condition? Man can eat or drink in horizontal position. If you tried, you could eat upside down. Blood circulation is not adversely affected because the important factor is the drag resistance of blood in veins and arteries. Gravity plays only a small part. You can lie horizontally in bed, get up, and your heart circulation is scarcely affected.

VEHICLE INTO ORBIT

IF WE assume that we have taken off in a rocket from a Pacific island and climbed into an orbit inclined about 65 degrees to the Equator, our ascent is on a northeasterly course. About 1,000 miles from the launch site, the last stage reaches terminal velocity. Since the ship has excess velocity above circular orbital speed at this alti-



tude, it recedes further from the earth unpowered and reaches apogee just 180 degrees on the right upper corner of the globe.

To establish circular orbit at 1,075 miles altitude, we need a short velocity adaptation at the apogee. This prevents the rocket from descending back to the perigee at 60 miles altitude. This speed adaptation is a minor maneuver requiring only about 15 seconds of power application.

Having given this "apogee kick" to the third stage, the rocket is now permanently established in a near-circular orbit 1,075 miles up. The ship would go around earth once every two hours. The earth will rotate inside the orbit once every 24 hours. So the orbiting rocket will pass the Equator at a different meridian each time.

An observer thus could view different parts of the earth on each revolution. Within a 24-hour period he would have opportunity to see every point on earth at least once.

INSTEAD of having a manned rocket circling the earth, it is possible to build a manned, permanent space station in orbit 1,075 miles up. But this requires a means enabling the crew to leave the ship. The orbit lies in the vacuum of outer space and so pressurized apparel would be required.

By employing a rigid container, pressurized within, the passenger could be shuttled around at will with small rocket engines. He would manipulate retractable tools or mechanical arms, similar to devices employed in atomic energy plants for handling radioactive material. Built-in gyroscopes would

allow the occupant to acquire any spatial attitude by using the precession force of the gyros.

Prefabricated sections for an orbital station could be carried to the exact point in space by chemically fueled boosters from a land base. Once in orbit, they could be assembled by operators in pressurized containers and thus provide a base of operations for interplanetary expeditions.

Returning personnel from orbit to the earth's surface is a more formidable task than the orbital flight. To raise an object into orbit is largely a matter of brute force, but to return human beings involves all the knowledge of modern science. We cannot afford to land a space rocket by slowing it down with propellants. We have to destroy the same energy on the way down that we imparted to bring it to orbital speed initially. Roughly, therefore, we would need the same amount of propellants to land a ship under rocket power alone as was required to place it in orbit. The fuel would become the payload for the ascent, and require a much larger ship.

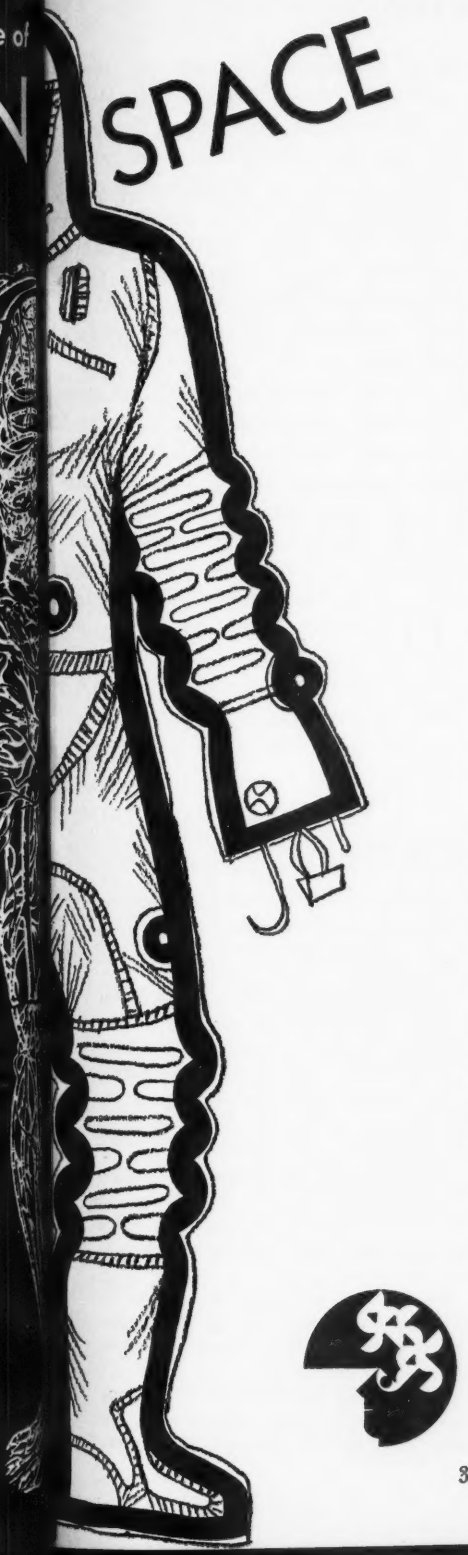
If we depend upon aerodynamic deceleration to get down, we can put the atmosphere to work. But this means reentry at a speed comparable to the orbital velocity of 18,000 miles per hour and gradually slowing down the ship.

This creates a formidable aerodynamic problem, but we have at least partially solved it by the recovery of ballistic missile nose cones. With means perfected to protect against excessive temperatures, many means can be used to direct the return to a desired point.

Meeting the physiological challenge of

MAN IN

SPACE



Colonel Robert L. Hullinghorst

FROM THE physiological standpoint, the greatest barrier to space flight at this time is related to man's ability to reason. This same ability which will make space travel a reality is inescapably based on man's environmental background and experiences. Such reasoning powers will be seriously upset by the many strange circumstances in which he finds himself on this great new adventure.

Isolated in an entirely new physical world fraught with life-endangering potentials at every moment, our astronaut will find much to think about, little to do. It has been predicted that his daily variations, his rhythmic cycles in behavior and bodily functions, will be markedly altered. There is good evidence that man in the weightless state will require little or no rest and sleep. This will leave him with much time to ponder the haunting uncertainty of his return to the normal behavior of terrestrial life with its many blessings of comfort and luxury.

One facet of this problem has been called the "break through" phenomenon. It has been noted by all who exceed 80,000 feet, though the exact height for each man is somewhat different. It will occur in each individual at the same height, however.

This phenomenon is a rather

COLONEL ROBERT L. HULLINGHORST, Medical Corps, is Chief, Research and Development Division, Office of the Surgeon General, Department of the Army.

sudden mixture of elation and sorrow, a feeling that all contact with the world has been severed and you are now a definite part of the vastness of space.

The phenomenon is not unlike the "raptures of the deep" that the experienced deep-sea diver has come to expect and deals with very effectively. It, too, is an eerie and constant feeling of unreality. It has been found that, in divers, this is a physical phenomenon in which nitrogen is acting as a narcotic—producing nitrogen narcosis. Perhaps we will find this "break through" into space is just such a physical phenomenon that need not long remain a mystery.

WHY MAN IN SPACE?

WHY do we want to get man into space? The physical scientists, particularly the engineers, are of late becoming anxious to place man inside their machines. Why?

Perhaps you may recall flying in an airplane when it was on "automatic pilot"; the flight was smooth and then, when the human pilot "took over," the flight may have become bumpy. Because of such associations, the general public often discounts man as the perfect machine.

Yet by the same token, no matter how complex, intricate and accurate the machine, it is still generally recognized that a man must be employed to replace a faulty bolt, oil a dry bearing, maintain a check on accuracy and even take over the controls when some wiring system burned out or a completely unpredictable occurrence took place for which the "robot" had no answer.

So the interest of the engineer is,

Machines Can't Do the Job

THE stars beckon, and man stands at the edge of his greatest adventure, the conquest of space. Will he recoil from it? History shows that he will not. Man has always been adventurous. The Sirens of the Unknown always have lured him. But not, as in mythology, to his own destruction.

At first, man trudged slowly on foot into the unknown to find fertile lands in the mysterious, distant reaches of his own continent. He stopped for a time at the shore of what appeared to be an endless expanse of water, but only for a time. Eventually he set sail, coming at last to inviting new lands, to new riches.

The explorations of ever-hopeful man have paid off, whether he was sailing over uncharted seas, or climbing mountains to see terrors or wonders or riches beyond, or working in a laboratory to learn something, no matter what.

SO TODAY man stands looking upward into space, even as the philosophers of old stared at the stars and tried by thoughts alone to solve the mystery of the universe. Today man knows a little more about space and the stars than the old Greeks knew. Not much more, yet enough to give him confidence that he can reach into space, and come back with new knowledge.

No one at the moment can say when the first man will take off into the infinity of space. The vehicle he uses must have utmost reliability, a living compartment that duplicates to the minimum necessary degree the conditions under which he can live, and means for safe return.

Why must men take this chance? Because no machine ever made or to be made can get all the facts that man wants and needs for the conquest and intelligent use of space. Indispensable man—and only indispensable man—can do the job.

in a purely scientific way, to increase the reliability of the machine. The engineers have demonstrated their ability to provide space flight—the Army Explorers show that—but to bring refinement or, as they say, "sophistication" to this travel they need a "repairer," a "corrector" and an "interpreter" of higher order than they can produce. Man, the instrumented marvel produced by the Great Engineer alone, is the only answer.

What benefits will accrue to man from space exploration and space travel no one can say. But the benefits of man's former explorations and travels could not be foretold, though the benefits from those ventures were so enormous as to be unbelievable to the people of that time. By analogy, Christopher Columbus' expedition in 1492 might be comparable, in our era, to man's first successful voyage into space, probably to the moon.

NATURE OF THE CHALLENGE

THE challenge of manned space flight is very complex. For the physical scientist space starts about 600 miles from the surface of the earth. But for the astrobiologist—the man dealing with living matter in space—space has a different meaning. For him, space begins in some details at 10 miles of altitude. All of the actual space phenomena affecting man are produced at a height of 120 miles.

Experimental test animals have been sent far beyond this and returned safe and unharmed. Man, the prize biological specimen, has not yet penetrated this area much above 20 miles. However, neither man nor animal has been subjected to this environment without protection; they must take some of the characteristics of our earthbound existence with them.

Unfortunately, it is not possible to take all terrestrial features along into space. At the heights and speeds of today's aircraft, the precautions taken are mostly a comfort factor, simulating as nearly as possible the earth's conditions.

Insofar as engineering skill will permit, a small earth must be created for the space traveler to live in. This miniature earth-like container will be very unlike the void surrounding the craft. In the present era of scientific achievements some limitations are necessary in the creation of an artificial earth vehicle.

Before man goes into space it will have to be safe to assume that the space vehicle will function properly; that the atmosphere within it will be livable and devoid of obnoxious odors; that the temperature will remain within acceptable limits; that the passengers will be protected from harmful radiation; and that the space vehicle can return safely to the proper place at the designated time. Moreover, the first astronauts must be provided with some comfort, some awareness of their terrestrial life, some feeling of accomplishment and most particularly with a realization of the valuable relationship they carry to their fellow men.

BIOPHYSICAL FACTORS

TO MAKE the engineer-designer's task easier and to allow him to provide manned space flight as soon as possible, the biological scientist needs to delineate the acceptable limits of tolerance which would be safe and comfortable for human passengers.

We know that the earth's surface atmosphere is relatively uniform, providing a twenty-one percent oxygen mixture at 14.7 pounds pressure. These are the conditions in which the human "machine" is most efficient and comfortable.

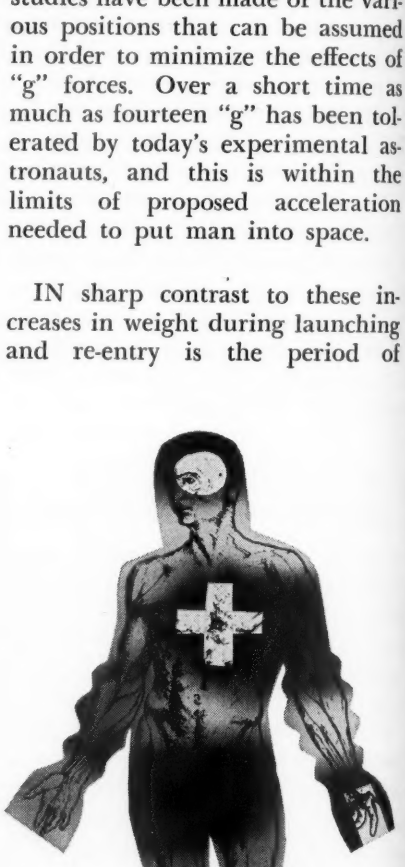
In order to help the engineer conserve weight, we can tell him there is no appreciable difference to our space traveler if he will provide half of the usual amount of air pressure and twice the percentage of oxygen.

Carbon dioxide, the body waste from utilized oxygen, presents a problem. Man can tolerate only relatively small amounts of this in the air he breathes. At first this carbon dioxide may be absorbed by chemicals. Later it may be possible to include plants in the container to convert the carbon dioxide back to oxygen, although such systems are not now practicable. In early satellites oxygen resupply will be from high pressure cylinders. The idea that expired air hangs in front of one's nose in the weightless state so that a man might literally drown in his own expired breath is both fanciful and unfounded. An adequate ventilating system would dispose of that, and would also provide dehumidification for removal of excess water vapor.

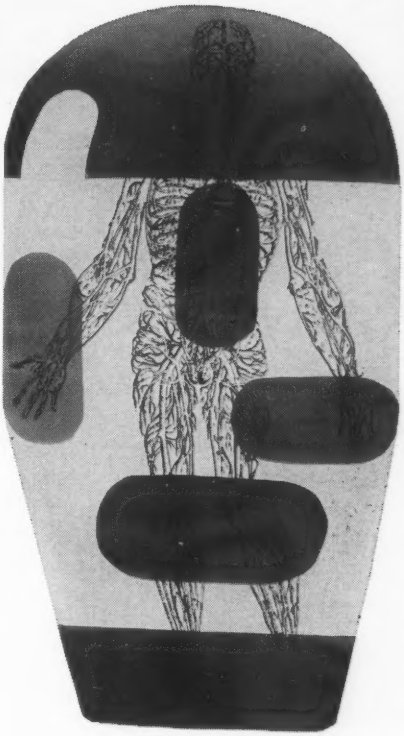
CONSTANT speed, in itself, has no effect on living matter. To appreciate this, we have only to realize that in our everyday life we are speeding with the earth at several thousands of miles per hour. The attraction of the earth for a body (gravity) is measured in terms of "g". To increase or decrease speed a force must be applied that is measured in one of these units, or 32 ft/sec/sec. Thus a one-hundred and eighty pound man weighs three hundred and sixty pounds at two "g".

It is apparent that such forces and weight increases will disturb the balance of man's bodily functions. But scientific research has now developed pressure suits and studies have been made of the various positions that can be assumed in order to minimize the effects of "g" forces. Over a short time as much as fourteen "g" has been tolerated by today's experimental astronauts, and this is within the limits of proposed acceleration needed to put man into space.

IN sharp contrast to these increases in weight during launching and re-entry is the period of



weightlessness in orbit. Man will experience an existence of no up, no down. All objects will stay in place in mid-air, moved only by the ventilating system, no matter how heavy they might appear on earth. The space traveler will be unable to pour water from a glass and will therefore receive his food and fluids from a toothpaste-like tube. Experiences thus far have been with extremely short exposures, but it appears that long exposures will not be deleterious to man. Apparently a man may become adjusted to this existence by training.



OUR present satellites are now rotating around the short axis like a bullet, and end-over-end like a propeller. It has long been known that man is comfortable over prolonged periods up to about four revolutions per minute. Figure skaters and others by training easily orient themselves to very high figures, on the order of 100 revolutions per minute.

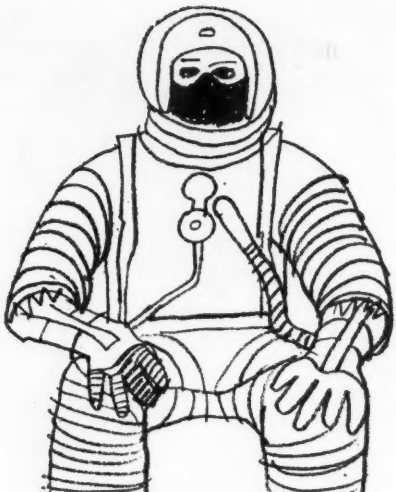
Perhaps designs may be achieved so that rotation of a low order will be of benefit to the man in space. Spinning a rock at the end of a string in a circle will demonstrate that there is an outward or centrifugal force; and this may provide a substitute for gravity.

A properly designed ship could be rotated at speeds necessary to provide one-third "g" by centrifugal force. Although there would be variations of force applied to the passengers, human centrifuge studies have indicated that the passengers would be comfortable enough to perform well.

EXTREMES of temperature on the outer shell have been reported by Explorer I, but it has been possible to maintain the temperature inside within limits tolerable for human survival.

Ordinarily the heat given off by man and the machines he uses would soon produce enough heat to roast him. To be adequate, the ventilating system must just offset the heat a man releases; and possibly the heat variables of the shell of the ship may be utilized for this purpose.

Human wastes may be deodorized and stored by the first space travelers on short flights. Later, wastes will be changed back into products man may use. This is what happens on the earth: animals use food, oxygen and water to



produce the energies of life; they expel wastes consisting of carbon dioxide, sweat, feces and urine. Plant life utilizes light with the carbon dioxide and other animal and vegetable wastes to produce oxygen, growth and fruit. At first, urine will be purified and reused. Later, we will learn to duplicate the complete terrestrial cycle: a balance of plant, light, and animal.

EFFECT OF COSMIC RAYS

SEVERAL forms of highly energized matter streak through outer space. For long trips it is clear that some screening device will be needed.

It has long been known that electrons "shot" at a metal plate in a vacuum will produce X-rays. There are vast electron clouds in the reaches of outer space, and our metallic satellite provides the target for the production of X-rays. Man has successfully coped with these and, as such, they present no major problem. There are, moreover, portions of the ultraviolet spectrum that do not reach earth's surface and are detrimental to plant and animal life. These are blocked by the atmosphere, principally a layer of ozone very high in our air blanket. The skin of the satellite should provide protection against ultra-violet rays coming from the sun. In the absence of any atmosphere around the satellite, the intensity of back scattered ultraviolet light should be insufficient to produce any detectible physiological effect.

MEN INTO SPACE

AFTER the astrobiologists have given the astronautical designers the requirements for man's survival in space and have outlined his requirements for comfort and the conditions for his useful behavior, it will be desirable to prove the soundness of their predictions by extrapolations from other animal travel as nearly simulating man-travel as possible.

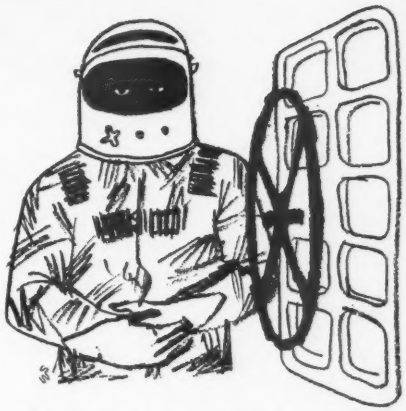
Next, a safety factor is required. Initially this will be an override mechanism controlled from earth so that man cannot harm himself if he is beset by the "break through," by carbon dioxide intoxication, or some unforeseen incident.

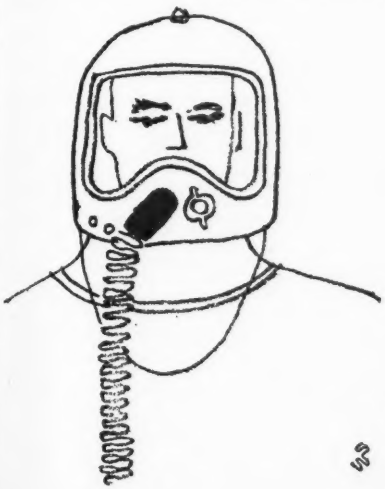
During this whole period of planning and building, the medical sciences must be selecting and training men for flight into space. There is no successful field of human endeavor but what the greater the selection and training, the greater the achievement.

Carbon dioxide tolerance, motion and force tolerance, auditory and vibratory tolerances vary greatly, and those with the greatest tolerances must be selected. The space traveler must be able to sort out the various sensory stimuli and learn to depend on only one or possibly two. He will have to believe his eyes, even though all of his other senses—balance, weight, touch—tell him differently.

To the psychologist and the analytic psychiatrists will fall the problem of selecting those who can adjust readily to a completely alien environment—men who will not become disoriented by their own actions which will be new and strange to them. One other requirement of our first space traveler—he must have a high order of intelligence, a broad background of experience in both biological and physical sciences. He must be our observer, our recorder, and our "correction factor" in the flight.

HAVING selected the proper persons, rigorous training must follow. Without our purposes and without the well-adjusted individual, this training will be akin to torture of olden days. Our prospective astronaut must be gradually trained to long periods of isolation from all ordinary stimuli. He must be trained to withstand extremes of force and motion, and to ignore vibratory and noise cycles. He will be akin to the sailor who experiences difficulty in losing his sea legs when alighting, for he will have been trained to ignore the sensory impulses of weight, gravity and balance.



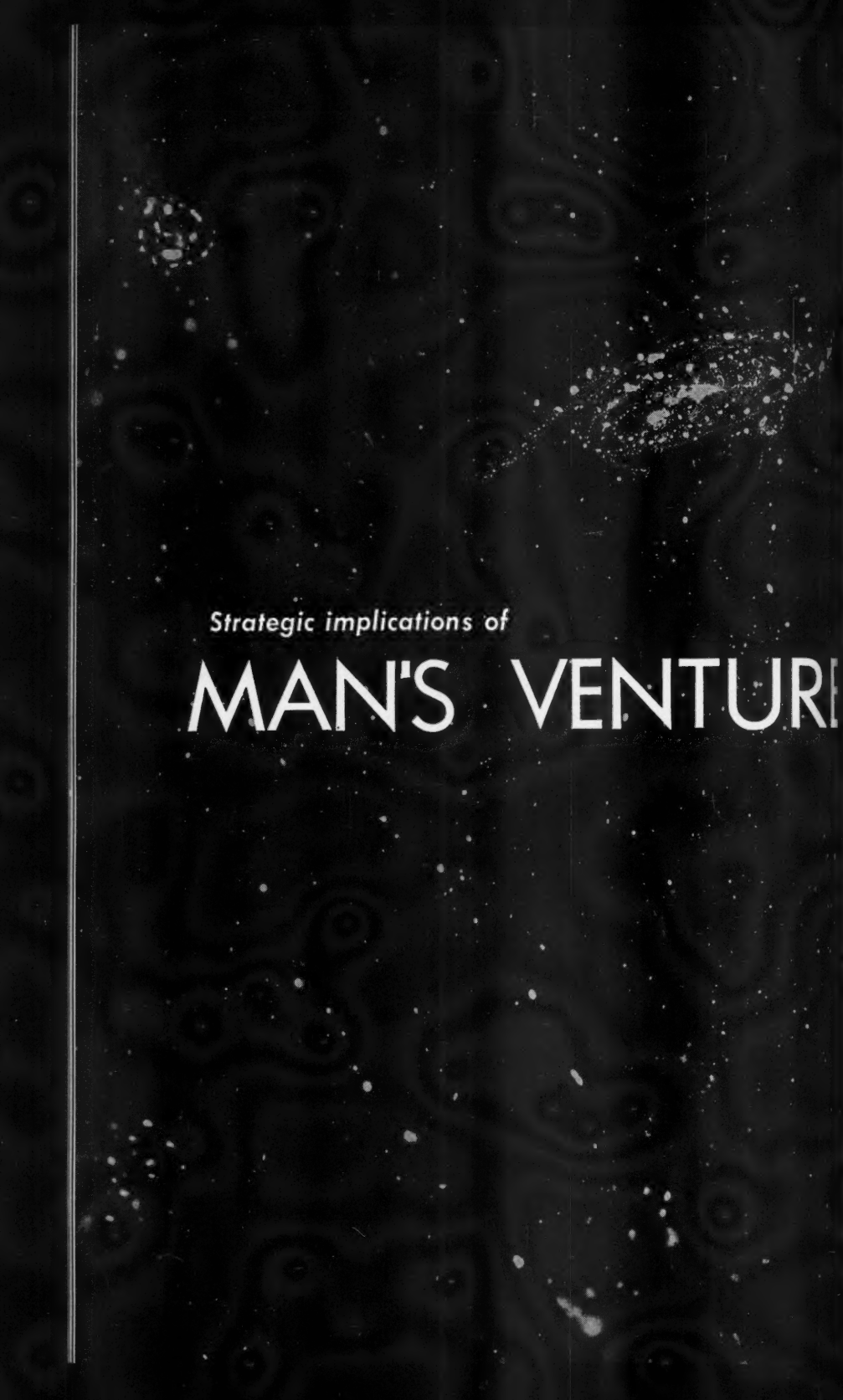


In training, our proposed traveler will be endowed with a sense of safety, the reality of return, and the urgency of accomplishment. He will become dedicated to the belief in the value of the flight and his achievement in the interests of mankind.

Above all, he will be made to feel that on his own reasoning, the success or failure of the mission hinges.

All elements in this enormous undertaking having been completed, there is only one very old element to consider. This is the moment of the calculated risk.

The stars beckon and man is ready for his greatest adventure—the conquest of space.


Strategic implications of
MAN'S VENTURE

"Then felt I like some watcher of the skies
When a new planet swims into his ken
Or like stout Cortez when with eagle eyes
He star'd at the Pacific—and all his men
Look'd at each other with a wild surmise—
Silent, upon a peak in Darien."

Keats

RE NTO OUTER SPACE

Lieutenant Colonel Roy L. Atteberry

MAN'S assault upon outer space has commenced. It is too early for us to go more than a few faltering steps beyond that condition of wild surmise which silenced that bold exploring band as they stared at the seemingly boundless Pacific. However, those faltering steps must be made and by free men, for implicit in this new dimension are both threats and hopes for the security of all free men.

LIEUTENANT COLONEL ROY L. ATTEBERRY, Artillery, is Chief, Policy Planning Branch, International and Policy Planning Division, Office, Director of Plans, Office of the Deputy Chief of Staff for Military Operations, Department of the Army.

Perhaps the most significant immediate result of this new assault lies not so much in its material achievements but in the effect it is having upon man's mind. Man must think in new or changed dimensions. Old limits are beginning to slip away. What will be revealed by their disappearance is still unknown, but we can be certain that the world will never seem quite the same as it did before the man-made satellites settled into their orbits.

Man has had this experience before and we have, therefore, some indication of what such an experience portends. The histories of the

Golden Age of Greece, the Renaissance and the Industrial Revolution furnish examples of what can occur when man rises to a new plateau of thought. Amidst the many generalities which can be made about these revolutions of thought, two are particularly important to the strategist.

The first is that many problems which plague man when he operates on one plateau of thought tend either to clear up or disappear, at least in a relative sense, when he finds himself on a higher plateau. While the mariner who sailed his craft in the Mediterranean still had his troubles, they became insignificant when compared with those of the captains who ventured after Columbus.

Thus, too, the seemingly unresolvable strife of the Italian city states which so long rocked the Mediterranean world became insignificant in the world revealed by the sixteenth century explorer. Man's long search for the philosopher's stone stopped before the fantastic wealth promised by the simple chemistry of the iron smelter.

The second strategic lesson to be derived from earlier revolutions in man's thinking stems from our knowledge of the fate of those men who were unwilling or unable to adjust their thinking to a new mental environment. Sparta is the classical example. While Athens flourished under the stimulation of Hellenic thought, Sparta declined for want of the mental flexibility necessary to breathe the new atmosphere.

It is well to note that physical capability to cope with new situations is not enough. Spain was perhaps the most capable, in the physical sense, to move into the outer space revealed by Columbus. In spite of its head start, the Spanish effort was a failure. While the reasons for this failure were many and complex, it seems fair to say that the underlying cause was a rigidity of the Spanish mind.

The pitfalls of a brave new world are not, however, entirely reserved for those of a rigid mind. There is the possibility of seeing too far and locking one's aim upon what, in fact, is a mirage. The political experience of Athens in its Golden Age may be an example of this. Certainly the liberal politicians of the Nineteenth Century

Mind Over Matter

PERHAPS the most significant immediate result of man's movements into space lies not in its potential material achievements but in the effect it will have upon the human mind. Man must think in changed dimensions. Just what is ahead no one can know for sure, but it is certain the world never will seem quite the same as it did before the Sputniks, Explorers and Vanguards went into their orbits.

Physical capability to cope with the new situations will not be enough. There must be mental agility and flexibility. Spain was perhaps the most capable in the physical sense to profit by the discoveries of Columbus in what then was unknown space, but the Spanish effort was a failure, mainly because the Spanish mind failed to rise to the new plateau of possibilities. Man is on the verge of the marvelous. What the exploration of space will do for him or to him depends largely on his intellectual capabilities.

with their unbounded confidence in "progress" as the resolvent of man's problems were guilty of fixing their sights on what appears now to have been a mirage.

This, then, is the first strategic implication of our position on the threshold of outer space. We must adjust our frame of mind to cope with an unknown but inescapable new environment. Not only must we move into outer space but we must be prepared for outer space to move into the world by way of the changes it will induce in man's mind.

NEW RELATIONSHIPS

AT PRESENT the significance of outer space lies not so much in its being a new dimension as in the effects its conquest has and will increasingly have on the old dimensions and measurements. Earth-bound distances, for instance, become insignificant in relationship to distance in outer space. In a sense, earth-bound distance has reached a limit roughly to 12,500 miles—since no two points on the surface of the earth can be further apart than this. The jump to outer space has caused man to think in terms of and deal with speeds of a completely new magnitude.

Earth-bound time factors in turn have been so collapsed that events previously measured in weeks, months and years are now measurable in seconds, minutes, hours and days. To a satellite orbiting the earth, there is no distinction between land, sea and air. They are merely insignificant variations and parts of a surface. Nor does weather or the time of day have any effect upon the satellite's operations. This upheaval in the factors

which have so long influenced strategic thought cannot but affect the old equations.

For some time to come, the focus of strategy will remain the earth itself and man's operations in outer space will take their principal significance from their effect upon men remaining on the earth. Perhaps man will in time cut himself loose from the earth and focus his attention upon distant celestial bodies as new lands, but this possibility is too far in the future, or imagination, for practical consideration at present. Our present practical military strategic problem, then, is to determine how an ability to operate in outer space will affect the concrete problems of defense and offense on earth.

WHEN man was still strictly land-bound, his strategic defense problem was to repel an attack from any direction upon a surface. Intelligent use of terrain and water barriers could greatly reduce the number of directions from which such attacks could take place, thus permitting him to concentrate his force against the most likely avenues of approach to his position. Offensively, his strategic concern was to maintain the greatest number of possible approaches to his enemy.

The advent of a capability to move on water greatly reduced the effectiveness of water as a barrier and consequently increased the avenues of approach to many defensive positions. In time this naval capability was able to capitalize on the hitherto unimportant fact that the surface upon which man lives is a curved one. Man found that he could attack an enemy lying to the east by sailing west. This also increased the number of approaches to the enemy, but man's operations were still tied to a surface—even though it was curved.

Additionally, the already complicated problems of operating on the land surface were increased by the problems of operating interchangeably on a land and water surface. With the advent of a capability to move in the air, tactical man was at last forced to look up but strategic man still looked in the compass directions for the threat against him.

Aircraft, by thickening the surface a bit, were able to increase the number of directions of attack, but were still unable to close the circle even on the surface. Large bodies of water are still a handicap to air attack across them; the highest mountains cannot be completely ignored; and weather remains a barrier of sorts.

SPACE AND STRATEGY

ASSUMING a capability to move freely in outer space, offensive man not only closes the circle of possible directions from which he can attack, but actually escapes the restrictions of the surface. Not only can he attack from any point on a circumference; he can attack from any point on the celestial hemisphere. If the defender has any positional security it lies in the ground beneath his feet.

The extent to which man's capability to move in outer space approaches the ideal of moving freely in outer space is the operational measure of the influence the new dimension will have upon strategy. This freedom of movement is likely to be restricted for some time.

So far, man's movements in outer space are limited to the inflexible path of the ballistic trajectory and the orbit of the satellite. Such flexibility as man enjoys in controlling these courses is still highly dependent upon his geographic and technical flexibility on earth.

Man is still a long way from even closing the compass circle around his enemies and this is likely to remain true so long as his vehicles which penetrate outer space must follow a rigid ballistic or orbital path. By a combination of range and mobile bases, the circle can be closed with the ballistic missile.

Taking the most easily analyzable case of a marine-based missile, we find that it requires a range of approximately 8,500 statute miles to hit any land target in the world from every direction.

Even when this range is rejected as unnecessary from a practical standpoint, one finds that long ranges are required to close the circle on specific targets.

FLEXIBILITY of what can be moved through outer space is as important as flexibility of how it moves. The foreseeable cost of moving significant loads of men or cargo through outer space will be very great—so great, in fact, as to

raise the question of what possible use the men or cargo could serve which justifies the effort. In other words, it would seem that the effectiveness of men and their possible accoutrement must be greatly increased before their transportation by this costly means can be justified. This, of course, is a different problem than the one of conquering outer space.

Even as vehicles for transporting pure firepower, outer space vehicles promise to be very costly. Even now, we can see that economic considerations are likely to restrict in some degree attempts to overcome the inflexibility of presently contemplated ballistic missiles by sheer mass of many missiles.

It is perhaps too early to judge whether more flexible future missiles will permit a sufficient reduction in the numbers required to offset the increased cost of the new missiles. In any case, the economic factors of operating in the new space age have enormous strategic implications which at present can be only vaguely seen. What little we now know of the probable power requirements alone of moving in outer space is sufficient to indicate that the cost will be great.

IN CLOSING this glimpse into the future, it may be appropriate to look at the "military" versus "civilian" aspect of the new age. Men may hope that this latest venture will be a strictly peaceful one, but the facts of history are that each advance of this nature invariably induces military strategic implications. We can only hope to be the first to detect these implications and act upon them in the best interests of the Nation's security.

Science looks to its hardware in

ADAPTING WEAPON and MATERIEL to t

Dr. Ernst Stuhlinger

THE MOON, Mars and the vast, challenging galaxies of the universe are coming into clearer focus in man's eyes. Not many years ago they were largely invisible and scantily known, if at all, to visionaries and idlers — those who had nothing better to do with their time and talent than to gaze into the heavens and speak of the wonders they dimly perceived.

The advent of the Space Age marks a reversal of attitude so swift and thorough that it amounts

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ONRY
t SPACE AGE

to a complete upheaval in thought. Relatively few fully recognize the significance of this recent, magnificent change in the affairs of earth's inhabitants.

Events of the past year have underscored the fact that we are now at last on the threshold of actual space travel. It is now established that existing technology is sound, as proved by early, fledgling steps to the edge of space. Established concepts need only to be advanced, gradually and unfalteringly.

The successive Ages of Sail, Steam, and Air are now giving way to the Age of Space, which will also employ men and machines, but machines of very advanced design responsive to automatic control. In this new age, as in the earlier ones, it is the military need which prompts and lends urgency to progress.

SATELLITES and outer space vehicles are close technological relatives of the modern weapons systems that are being developed as intermediate range and intercontinental ballistic missiles. The same propulsion systems, and much the same order of efficiency in guidance and control systems, will

serve initially the weapon, the scientific investigation, and the space vehicle. These are all fruits of the same tree.

For the foreseeable future, progress in space exploration is dependent upon ballistic missiles. Other proposed means of propulsion to carry man into deep space will not be available for several years.

A number of outstanding examples of the adaptation of military weapons and materiel to space investigations can readily be cited. One of the first such adaptations came in 1949 when Army personnel developed and successfully launched Bumper experimental missiles—a combination of the V-2 and the American Wac Corporal. These missiles, launched from the New Mexican desert, carried payloads of scientific instruments provided and installed by some of the Nation's leading research institutions. The flights proved on a large scale, for the first time, the feasibility of staging rocket propulsion units, one on top of the other —now a common, useful system.

The same general principle was employed by the Army in launching the Free World's first scientific earth satellite by means of the Jupiter-C composite reentry test missile. The Redstone missile, a military weapon now deployed with Army field forces, was used as the main propulsion unit, capped by three additional solid propellant stages. Relatively few modifications were necessary on the booster, and the cost of the project was modest.

Other instances of this dual role to which military weapons can be adapted are evident in the current use of the Nation's two intermediate range ballistic missiles. The United States is using the Thor and the Jupiter as basic units for exploration of space.

PROPULSION IN SPACE

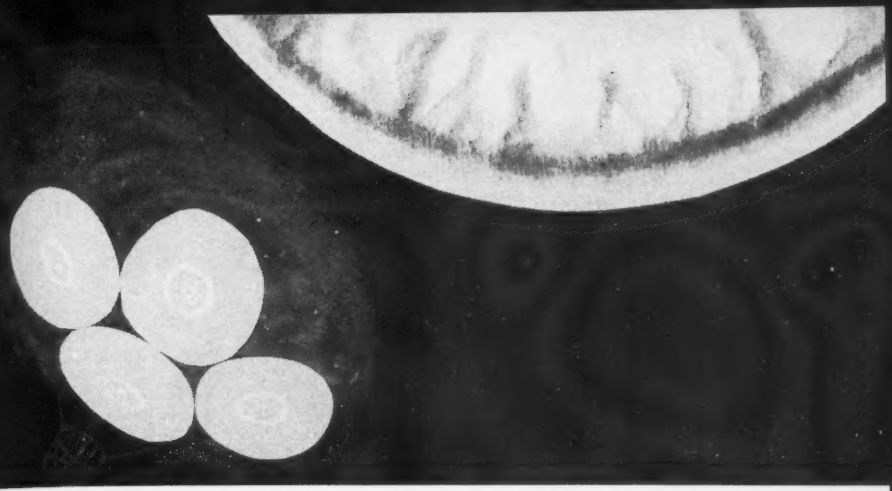
IT IS well known that the only means of propulsion in outer space is some type of rocket. As stated in Newton's laws of motion, one mass can be accelerated only by having a force push between it and another mass. In space it is essential that the second mass be carried aboard the vehicle and ejected from it—and this is the fundamental principle of rocketry.

Four basic types of power plants

Can the Missile Men Hit What They Shoot At?

THE ANSWER is Yes. It can now be said with certainty that the accurate guidance of earth-bound missiles is a present-day reality. The all-inertial guidance systems developed for the Army's Redstone and Jupiter make it possible to deliver a warhead with extreme accuracy over a wide bracket of ranges up to 1500 or more nautical miles. Similar accuracy is attainable for the ICBMs. Future work on these weapons will be devoted mainly toward improvement.

Development and improvement of these missiles is of prime importance in space exploration, which up to now and for the future—as far as can be seen—is dependent wholly on ballistic missiles. The same propulsion systems, and much the same order of efficiency in guidance and control systems, will serve initially the weapon, the scientific exploration, and the space vehicle. As with the Air Age, it is military need that lends urgency to progress.



have been conceived for achieving this result. They range from a system that has been in use for many years and has reached a high state of perfection, to one that is little more than a gleam in the scientist's eye.

In the first, commonly used type, the propellant gas is accelerated by heat energy generated by chemical reactions. This is the most fully developed system and is the one used in all rockets fired to date. Its relatively small payload-to-fuel ratio causes it to be accepted only as a stopgap form of outer space propulsion.

Another method involves acceleration of a gas by heat energy from nuclear reactors, electric arcs or the sun. In this system the large power plant weight constitutes an initial handicap that can be compensated only by higher exhaust velocities, with the achievable velocity being limited only by the heat resistance of the structural materials. Using pure hydrogen, exhaust velocities in the order of 6000 meters per second can be attained. It is possible that nuclear reactor heating will be superior only for vehicles whose take-off weight is in the order of several hundred tons.

The third propulsion system is an electrical operation in which the propellant would be converted to ions accelerated by electric fields, or by combined electric and magnetic effects. Much higher exhaust velocities can be reached by electrical than by thermal acceleration. Also, the exhaust particles would be so directed that they would not strike the thrust chamber walls and hence the heat resistance problems would be much less severe.

The last system is the only one for which little basic scientific knowledge is available today. This system would involve the emission of photons creating thrust because of the momentum which they impart on emission.

POWER PLANTS

IN THE field of power plants, two major problems persist. The basic one involves pushing the scientific frontiers into the as-yet-undeveloped types of propulsion systems which are more attractive for potential space exploration. The other is the engineering of larger power plants of the more conven-

tional types which will be necessary for the initial phases of manned space investigation.

The most attractive approach to actual space travel with known propulsion entails the establishment of manned space satellite stations; these would provide take-off points for vehicles powered by the more efficient space propulsion systems already discussed. Advanced systems, such as the electrical and electro-magnetic, are quite efficient in their utilization of fuel; however, they yield a very low thrust that would be totally inadequate for overcoming gravity and the atmospheric drag of earth.

GUIDANCE FOR SPACE VEHICLES

ANOTHER major problem area in exploring space is the matter of guidance and instrumentation for space vehicles of the future. This has been one of the biggest areas of concern for the developer of ballistic missiles in recent years.

Accurate guidance of earth-bound ballistic missiles is already a reality. For example, the all-inertial guidance systems developed for the Army Redstone and Jupiter missiles afford the capability of delivering a warhead with good accuracy over a wide bracket of ranges up to 1500 or more nautical miles. Similar accuracy is attainable for ICBMs. Future applications will necessarily emphasize product improvement, component miniaturization, and improvement of reliability.

Attention is being constantly given to the reduction of size, weight and complexity of guidance and instrumentation components. This is being accomplished by elimination of redundancy and by a concentrated program of size reduction popularly termed "micro-miniaturization."

Large electro-mechanical guidance computers are no longer tolerable, and heavy cabling and electrical networks must give way to printed circuit and cable techniques. The problem of micro-miniaturization is somewhat frustrating since reduction in size cannot easily be made to go hand-in-hand with high accuracy and reliability. This is balanced by the fact that as weight is reduced, redundancy becomes less serious.

As development efforts proceed on more sophisticated satellites for specialized applications, the accomplishment of many missions will be dependent upon extreme accuracy, both in guidance required to place the satellite with precision into the proper orbit, and in the instrumen-

tation with which the satellite must sense and communicate its environment and position as functions of time. Achieving precise orbits in terms of perigeal and apogeal distances, equatorial inclination, and orbital period will require extreme accuracy in thrust termination and velocity control of the launching vehicle, and in the azimuth and pitch angles with which the satellite is injected into orbit.

ACCURACY FACTORS

ANOTHER significant, logical step in the exploration of space will be the performance of lunar and interplanetary probe experiments with unmanned, instrumented vehicles. For such missions, the requirement for guidance accuracy will be acute. Trajectories and orbits for such missions must be evolved from a multi-body problem in celestial mechanics.

The trajectory for a lunar probe, for example, is significantly influenced by the gravitational effects of the sun. The development of a guidance system to achieve such a trajectory requires the selection of components and schemes based on error allowances approaching the infinitesimal.

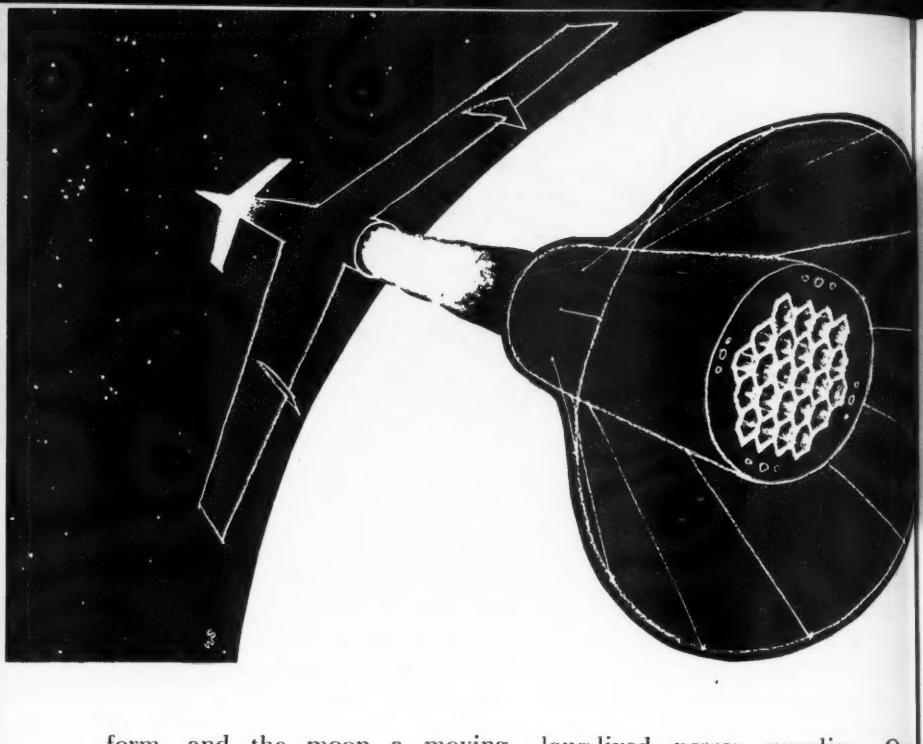
One of the more interesting probe experiments which can be attempted is that of obtaining photographic pictures of the back side of the moon. For proper appreciation of the space vehicle accuracy problem, it would be helpful to cite a few of the parameters involved in such an experiment.

Assume that the guidance to be used will involve only the inertial guidance of the boosting vehicle—that is, guidance by initial trajectory shaping only. If scientists are interested in passing the back side of the moon at an altitude of a few thousand miles, the following accuracy is required in launching:

1. Cutoff velocity of the last propulsive stage must be accurate to within one part in 1000.

2. Injection of the vehicle into the earth-lunar ellipse must be accurate within one-fourth of a degree.

3. If there is to be no continuous aiming of the launching platform, and continuous changes in the boost-phase of the trajectory tilt program, the time of firing must be achieved within one to ten seconds, since the earth may be considered a rapid-rotating firing plat-



form, and the moon a moving target.

The accuracy problem for lunar and interplanetary probe vehicles may eventually find its solution in the use of on-board mid-course and terminal guidance. These correction devices could employ radio-command, infra-red homing, inertial guidance or a combination of these. The basic problems then become those of payload weight and communications.

PAYLOAD AND POWER SUPPLY

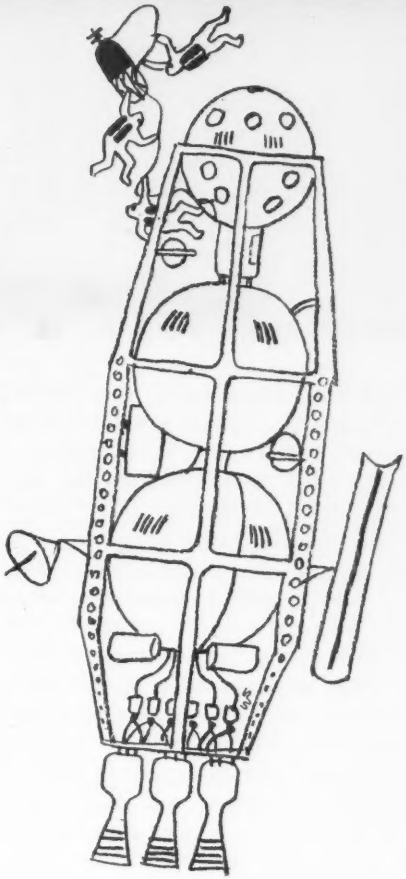
BECAUSE of the high cost per pound of payload weight in terms of propulsion and propellant requirements, every pound of space-vehicle payload will be worth many times its weight in gold. Thus it becomes necessary to obtain the utmost in microminiaturization of guidance and instrumentation components. This can be done only if at the same time there are developed lightweight, high output, long-lived power supplies. Outstanding in this field has been the development of solar cells by the Army Signal Corps for the Navy's Vanguard project.

The problem of power supply is especially acute in connection with the transmission of telemetry data and guidance intelligence from space vehicle to earth, and vehicle to vehicle. Data transmission over interplanetary distances will require extremely high-power transmitters.

Use of narrow beam antennas will reduce the transmitter power requirements, but will demand the application of advanced tracking circuitry and techniques to keep the beam directed toward the receiving station. The communications problem must also be attacked at the receiver end through revolutionary reductions in receiver noise levels.

Development of manned orbital and space carriers will not lessen

the overall guidance problem. While a human passenger will be capable of applying certain navigational corrections to the vehicle, man's limited reaction time will require that the major guidance burden be borne by electronic and electro-mechanical devices. These devices must be designed to give the ultimate in reliability to provide the highest possible degree of safety for the human occupant.

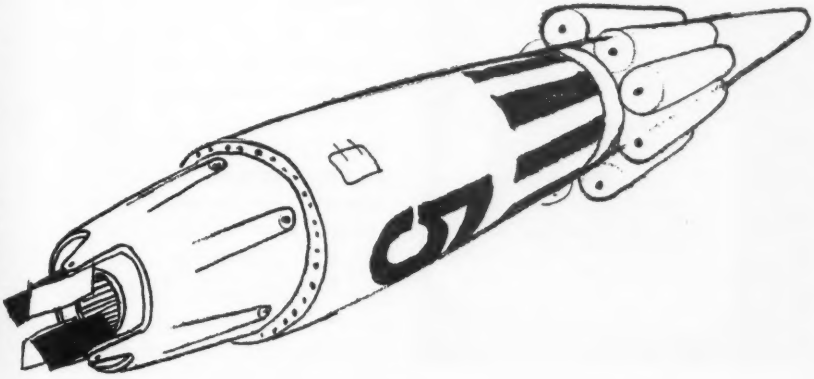


CONSTRUCTION FEATURES

IN THE actual construction of space vehicles there are two broad theories of approach. Construction technique will depend on information on cosmic rays and cosmic dust now being gained from unmanned satellites. As these investigations proceed, space technique can follow either of two courses. Professor Hermann Oberth of the Army Ballistic Missile Agency prefers to call these "the courses of the thick and thin walls."

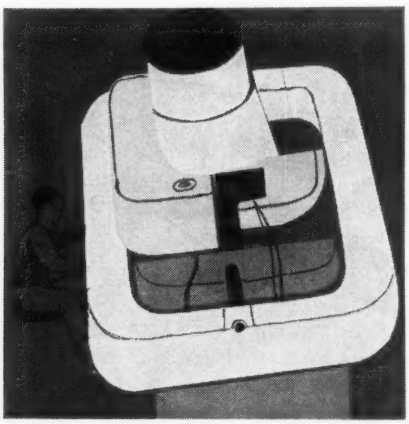
Space travel will be possible in either case, Oberth believes.

If the human body is able to withstand cosmic radiation, the space vehicle's walls can be made of exceedingly thin and light material, so that few "secondary" rays



would be encountered. For protection against cosmic dust the walls of the vehicle may be constructed along the lines suggested by Dr. Wernher von Braun—a protective shell placed around the whole at a distance of one or two inches. Under this arrangement, when cosmic particles strike the outer shell their high speed will cause most of them to heat and evaporate. The diminished force of the remaining particles will not be sufficient to damage the inner or actual vehicle wall.

Space technique will take an entirely different course should the human body be found incapable of withstanding cosmic radiation. In that case, space vehicles with small, thick-walled cabins may be launched. Their insulated compartments would afford continuing protection for human occupants.



It is strongly believed that man, even under the heavy cosmic ray condition, can allow himself to be exposed for brief periods without harm.

Once such a thick-walled space station has been established, and a space ship is available for distant travel, it will then be possible, Oberth suggests, to obtain from the moon materials needed for protective walls for further human space shelters. This thick-wall approach is not the simplest method, but it appears feasible if necessary.

FOCUS ON SPACE

UNTIL an advanced state of unmanned space exploration is reached, man cannot know with certainty what manned space travel will be like, or what direction space warfare will take if the necessity ever arises. Many ideas and proposals on space warfare have been advanced, debated and considered —but the fact remains that existing concepts of manned space travel are unproven, and only time and experience will tell which ideas were good and which were bad.

The dawn of the Space Age has opened the way to almost limitless possibilities. Science and technology are advancing at a constantly accelerating rate. Today man faces greater challenges to his imagination than to his ingenuity.

MEN OF THE MISSILE COMMAND

AMONG the men of the Army Ordnance Missile Command who provide the leadership for the Army's space exploration programs are the following, who form the Free World's most experienced missile and space team:

MAJ GEN. J. B. MEDARIS, 55, Commanding General of the Missile Command, directs the Army's activities in the missile and space exploration fields. Born at Milford, Ohio, and educated at Ohio State University, his military service began as a Marine private in 1918. Possessing wide experience in Army Ordnance and missile fields, he commanded the Army Ballistic Missile Agency from its inception in February 1956, until the new AOMC was formed in March 1958.

MAJ. GEN. H. N. TOFTOY, 56, until recently Deputy Commanding General of the AOMC, has been associated continuously with the Army Ordnance missile program since World War II. He recommended bringing to this country German scientists and engineers who had pioneered in rocketry. For four years, he commanded Redstone Arsenal. A 1926 graduate of the U. S. Military Academy, he is scheduled to become Commanding General of Aberdeen Proving Ground, Maryland.

BRIG. GEN. J. M. COLBY, newly designated Deputy Commander of Army Ordnance Missile Command, previously commanded the Ordnance Ammunition Command at Joliet, Illinois, and Frankford Arsenal in Philadelphia. A native of Iowa, Gen. Colby was graduated from the U. S. Military Academy in 1929. Much of his career has been devoted to design and manufacture of tanks, and to production of ammunition, including nuclear weapons, warheads and solid propellants.

BRIG. GEN. JOHN A. BARCLAY, 48, native of Colorado Springs, Colorado, was deputy commander before becoming commander of the Army Ballistic Missile Agency in March. A 1931 graduate of the U. S. Military Academy, he later received an M. S. degree in engineering from Massachusetts Institute of Technology. His extensive military service has been in Field Artillery and Ordnance.

DR. WERNHER VON BRAUN, 45, is director of Development Operations Division, ABMA. A world-famous rocket and space authority, he won his doctorate in physics from the University of Berlin at age 22 and has been a leader in rocketry since that time. He led scientific teams that developed the Army's Redstone and Jupiter missiles and launched the Free World's first scientific earth satellite. Employed in the U. S. Army missile program since 1945, he became an American citizen in 1954.

DR. WILLIAM H. PICKERING, 48, has been director of the Jet Propulsion Laboratory at the California Institute of Technology since 1954. JPL and ABMA are jointly responsible for the Army's space activities. Born in Wellington, New Zealand, Dr. Pickering holds three degrees in physics from Caltech. He is a member of the U. S. National Committee Technical Panel on the Earth Satellite Program, and is chairman of its working group on tracking and computation.

DR. JACK E. FROELICH, 37, head of the Design and Power Plants Department of JPL, is the technical director of that agency's space work. Dr. Froelich, who holds three degrees from Caltech, served in the Marine Corps during World War II as a project engineer and test pilot. He joined JPL in 1949 as a research engineer, and has been in his present position since 1955.

EBERHARD REES, 50, is deputy director of ABMA's Development Operations Division, working under Dr. von Braun. He received his technical education at Stuttgart and at the Dresden Institute of Technology, Germany. During World War II he served as technical plant manager of the Guided Missile Center, Peenemuende.

DR. ERNEST D. GEISSLER, 42, is chief of the Aeroballistic Laboratory at ABMA, the unit responsible for mapping satellite trajectories and similar planning. Educated at the Technical University of Dresden, Germany, he formerly worked at Peenemuende in missile stability and control.

DR. HELMUT HOELZER, 46, directs the ABMA Computation Laboratory and is in charge of computing missile trajectories and satellite orbits. A graduate of Technical University, Darmstadt, Germany, he has been active in the electronic computation field for many years, and holds several patents for advanced analog computers.

HANS H. MAUS, 52, is chief of the Fabrication Laboratory, which modifies and prepares the Army weapons for space missions. A graduate of the technical schools at Darmstadt and Munich, Germany, he was engaged in rocket production at the Guided Missile Center, Peenemuende.

DR. WALTER HAEUSSERMANN, 48, a graduate of the Stuttgart and Darmstadt technical universities, is chief of ABMA's Guidance and Control Laboratory, which was responsible for developing the Jupiter-C and Jupiter guidance systems. He has pioneered in this field in the United States and Germany.

HANS HUETER is chief of the Launching and Handling Equipment Laboratory, where the big missiles' ground equipment is developed. A native of Bern, Switzerland, he received his technical college education in Mittweida, Germany. He has been in Army rocket and guided missile work since 1932.

DR. KURT H. DEBUS, 49, is chief of the ABMA Missile Firing Lab at Cape Canaveral, Florida, where the Jupiter-C and other Army missiles are launched. A graduate of Technical University, Darmstadt, he was chief test engineer at Peenemuende. His experience in the guided missile field dates back to 1940.

WILLIAM A. MRAZEK, 47, directs the Structures and Mechanics Laboratory at ABMA in the research, design and development of missiles in such areas as configuration and propulsion. Educated at the Technical University of Bruenn, he was formerly engaged in German rocket programs.

DR. ERNST STUHLINGER, 44, heads the ABMA Research Projects Laboratory where much of the planning on Army space missions is conducted. A physicist, he was educated at the University of Tuebingen and was concerned with missile guidance at Peenemuende. Before World War II he worked with Dr. Hans Geiger, developer of the Geiger counter.

ERICH W. NEUBERT, 48, heads the Systems Analysis and Reliability Laboratory, which is concerned with assuring reliability of missiles in flight. A former design and consulting engineer, graduate of the Institute of Technology at Darmstadt, he joined the German guided missile program in 1939.

KARL L. HEIMBURG, 48, is director of the ABMA Test Laboratory, which checks all missiles prior to firing. Educated at Darmstadt, he worked in the development of the power plant and related components for the V-2 and Wasserfall missiles.

HEINZ HERMAN KOELLE, 33, heads the preliminary design section in the Structures and Mechanics Laboratory. A graduate of Bender Oberschule in Breslau and the Institute of Technology, Stuttgart, he founded the Society for Space Research in Stuttgart in 1952, and was formerly secretary of the German Rocket Society.

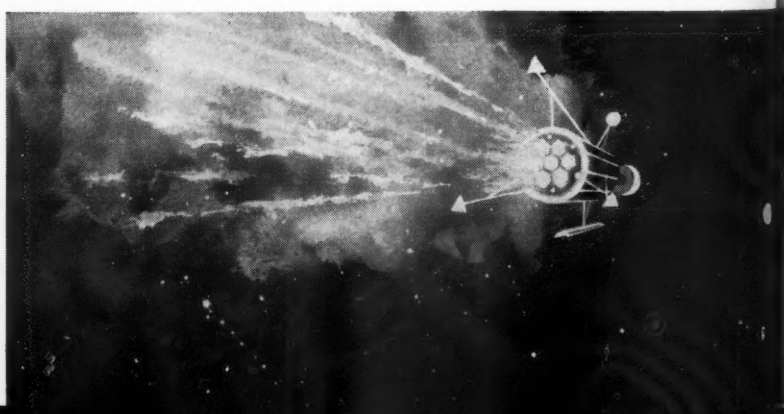
DR. HANS F. GRUENE, 49, is deputy chief of the ABMA Missile Fir Laboratory. Educated at the Technical University of Braunschweig, he w a research engineer at the Peenemuende Guided Missile Center.

ROBERT E. LINDSTROM, 29, staff assistant in the Structures and Mecha Laboratory, is coordinator for the ABMA satellite-space projects. A grad ate of the University of Illinois and a former Army enlisted man, Lin strom helped develop Army misiles during his military service and co tinued as a civilian after discharge.

C. I. CUMMINGS, 35, is JPL's chief of Systems Engineering Divisi Holder of a B. S. degree in physics at Caltech, he served with the Ar Signal Corps during World War II, and has been employed by J since 1946.

DR. A. R. HIBBS, 34, of Akron, Ohio, is chief of the Research Anal Section, JPL. Holder of three degrees in physics from Caltech and University of Chicago, he has been associated with JPL since 1950.

DR. H. L. RICHTER, JR., 31, is supervisor of JPL's New Circuit Elem and Stable Oscillator Research Groups. A former Navy instructor in e tronics, Dr. Richter studied chemistry at Caltech, and has been associ with JPL since 1955.



COMMAND LINE

ON STEPPED-UP ROCKET DELIVERY CAPABILITIES

"On 22 May of this year, a letter addressed to me by the director of the Missile Firing Laboratory at Cape Canaveral, Florida, was delivered to me in the Pentagon. It was a very unusual and significant letter because it had been carried in the tactical warhead of an Army Jupiter missile over 1,000 miles through space, and dramatically demonstrated the Army's completely successful solution of the problem of protecting a missile nose cone and its contents against the intense heat generated when it re-enters the earth's atmosphere at supersonic speed. The solution of that problem was basic to the development of a successful Intermediate Range Ballistic Missile. That letter is evidence of a 'first' for America which we have every reason to believe has not yet been matched by any other nation."

The Honorable Wilber M. Brucker, Secretary of the Army before the 30th Infantry Division Association, Washington, D. C., 11 July 1958.

ON INITIATIVE IN RESEARCH

"In Army Research and Development work, just as on the battlefield, the same rule holds: Advance! Safety Lies Forward! We can dig in, stay where we are, refuse to progress (and get whipped)—or we can take the initiative and move forward to success and victory. Our national attitude and policy must have equally positive objectives."

Lieutenant General Arthur G. Trudeau, Chief of Army Research and Development, before California State Chamber of Commerce, Los Angeles, California, 9 April 1958.

ON JUPITER'S RECORD OF ACCOMPLISHMENT

"All-in-all—counting our experience with the Jupiter-A, the modified Redstone which preceded Jupiter-C as a test vehicle; the Jupiter-C, and the Jupiter itself—the Army has attempted 39 launchings of the big missiles in its Jupiter program. Thirty were successful—completely successful—shots. They accomplished everything planned. Seven were partially successful—they all had successful launchings, but then, for various reasons, did not entirely meet the scientific requirements which had been set up. Only two—both early test vehicles—did not score at all. Americans have every right to be tremendously proud of this splendid record!"

The Honorable Wilber M. Brucker, Secretary of the Army before the 30th Infantry Division Association, Washington, D. C., 11 July 1958

ON TELESCOPING TIME

"In creating our missile systems, we are always working against time—time needed to develop prototypes for components of the system, time needed to produce these components, and time needed to train soldiers to man the system. To save time, we must compress and overlap research and development, production, and training programs."

The Honorable Wilber M. Brucker, Secretary of the Army, at the Army Missile Orientation and Demonstration, Fort Bliss, Texas, 30 June 1958.

THE U. S. ARMY—A KEY TO PEACE